Port of Seattle

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June 18, 1990

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Brinn Aurelius
Shell Oil Company
900 Louisiana, Suite 4860
Houston, Texas 77002

Reference: "Report of Subsurface Contamination Studies, Terminal 18, Port of Seattle"

Brinn Aurelius:

Please find attached the report you requested. The petroleum product contamination study was conducted by GeoEngineers for the Port and was finalized in November 1988.

Please call me at (206) 728-3190 with any questions.

Most sincerely,

David Aggerholm, Manager, Environmental Management

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REPORT OF
SUBSURFACE CONTAMINATION STUDIES
TERMINAL 18, PORT OF SEATTLE
HARBOR ISLAND
SEATTLE, WASHINGTON
FOR
PORT OF SEATTLE

GeoEngineers

November 28, 1988

Consulting Geotechnical
Engineers and Geologists

Port of Seattle
P.O. Box 1209
Seattle, Washington 98111

Attention: Mr. Doug Hotchkiss

Gentlemen:

We are submitting six copies of the results of our studies for the former Shell Oil Company property on Terminal 18, Port of Seattle, Seattle, Washington. Our services were authorized by Mr. Walter D. Ritchie on November 10, 1987. Contractual terms for our services are described in Agreement No. P009410 between GeoEngineers, Inc. and the Port of Seattle.

We appreciate the opportunity to be of service to the Port of Seattle. Please call if you have any questions regarding our report.

Yours very truly,

GeoEngineers, Inc.

James A. Miller
Principal

JHB:JAM:cs

File No. 0303-24-4

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Geo Engineers

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GeoEngineers

REPORT OF

SUBSURFACE CONTAMINATION STUDIES

TERMINAL 18, PORT OF SEATTLE

HARBOR ISLAND

SEATTLE, WASHINGTON

FOR

PORT OF SEATTLE

INTRODUCTION

This report presents the results of our subsurface explorations and related studies of the former Shell Oil Company property located at Terminal 18, Harbor Island, Seattle, Washington. The site of the former Shell bulk petroleum product terminal is located east of 11th Avenue Southwest on the northeastern portion of Harbor Island. The site location and surrounding features are shown in Figure 1. The general layout of the former Shell bulk terminal during 1975 is shown in Figure 2.

Services performed by GeoEngineers during the initial phase of this project included review of past land use in the area and preparation of a work plan for subsurface explorations and testing. Subsurface explorations, sampling, and analyses at the site were completed during three phases of field investigations in 1987 and 1988.

PURPOSE AND SCOPE

The purpose of our services is to explore and evaluate subsurface petroleum-related contamination at and adjacent to the former Shell Oil Company property on Terminal 18. The scope of services completed during this study includes:

1. Subcontracting and monitoring the drilling of thirteen soil borings to depths of about 15 to 20 feet. Nine borings (MW-1 through MW-9) were completed during the first phase of exploration, three borings (MW-10 through MW-12) were completed during the second phase of exploration and one boring (MW-13) was completed during the final phase of exploration.
2. Constructing 2-inch-diameter PVC monitor wells in the thirteen borings.
3. Measuring ground water levels and free product thicknesses on several occasions in the monitor wells installed by GeoEngineers and in six other monitor wells which existed prior to this study.
4. Measuring hydrocarbon (combustible) vapor concentrations within the monitor well casings.
5. Measuring the pH, conductivity and temperature of ground water from the monitor wells installed by GeoEngineers.
6. Collecting samples of ground water from eleven of the monitor wells and analyzing the ground water samples for the presence of benzene, toluene, xylenes, ethylbenzene, chlorobenzene, dichlorobenzene, petroleum hydrocarbons, organic lead and total lead.
7. Collecting a sample of free (floating) petroleum product from two of the monitor wells and analyzing the product samples for product type, API gravity and flash point.

8. Preparing ground water elevation contour maps based on our field measurements.

9. Evaluating the direction of ground water flow based on our field measurements and the ground water contour maps.

10. Developing estimates of the hydraulic conductivity of soil beneath the site.

11. Evaluating the results of the analytical testing of ground water samples.

12. Monitoring a pumping test to evaluate free product recovery options in the vicinity of Monitor Wells MW-7 and MW-12.

13. Developing recommendations for remediation of free petroleum product, treatment of recovered ground water, and future subsurface monitoring at this site.

HISTORIC AND CURRENT LAND USE

INFORMATION SOURCES

Information concerning historic land use at the former Shell Oil Company property and adjacent areas has been obtained from interviews with representatives of the Port of Seattle and Washington Department of Ecology (Ecology), Ecology's files pertaining to Shell Oil Company operations on Harbor Island, available reports, and aerial photography, including:

1. Black & Veatch, Preliminary Investigation - Phase 1 Description of Current Conditions, Harbor Island, Seattle, Washington, prepared for State of Washington, Department of Ecology, June 6, 1985.

2. CH2M-Hill, Inc., and Ecology & Environment, Inc., Draft: Remedial Action Master Plan, Harbor Island, Seattle, Washington, prepared for U.S. Environmental Protection Agency, October 4, 1983.

3. Corps of Engineers, Aerial Photographs of Harbor Island and vicinity from COE Survey Branch files, dated 1940, 1966, 1970, 1976, 1977, 1978, 1979, and 1985.

4. Harper-Owes, Duwamish Ground Water Studies, Waste Disposal Practices and Dredge and Fill History, prepared for Sweet, Edwards and Associates, Inc., Bellevue, Washington, March 1985.

5. Hart-Crowser, Geochemical and Geotechnical Engineering Study, Terminal 18 - Intermodal Yard, Seattle, Washington, prepared for Port of Seattle, July 9, 1987.

6. Port of Seattle, Construction, As-Built and SMA Permit Application Plans from Port of Seattle files.

7. Shell Oil Company, Letter to Port of Seattle, June 29, 1987.

8. Shell Oil Company, Letter to Port of Seattle, December 1, 1987.

9. Sweet, Edwards and Associates, Inc., Draft Report: Duwamish Ground Water Studies, prepared for METRO, March 31, 1985.

Information from the sources listed above was compiled into the map presented on Figure 3.

HARBOR ISLAND

Harbor Island and the surrounding region consisted of tidelands and river delta topography at the mouth of the Duwamish River prior to 1895. Dredging for construction of the East and West Duwamish Waterways and the main navigational channel of the Duwamish River began in about 1895.

Harbor Island is a manmade island (about 455 acres) which was formed primarily from dredge spoils generated during excavation of the East and West Duwamish Waterways during the period between about 1895 and 1910. Dredging for maintenance of channels and construction of terminals has occurred on a periodic basis since the early 1900s.

Sediments were dredged and used as fill for the northern portion of Terminal 18 (north of the former Shell property) during 1966 and 1967. It appears that dredge spoils have not been used as fill after the early 1900s in the portion of Terminal 18 that is the subject of this study.

FORMER SHELL BULK TERMINAL PROPERTY

Shell Oil Company has operated three petroleum tank farms with separate containment walls on the northeastern portion of Harbor Island in the past. Two of these tank farms remain in operation and are located west of Southwest 11th Street. The third Shell tank farm was located east of Southwest 11th Street at Terminal 18 (formerly Pier 19) and is the subject of this study. The locations of the three Shell tank farms are shown in Figure 3.

The former Shell bulk plant at Terminal 18 covered an area of about 12.5 acres. Shell Oil Company purchased the majority of this property in 1924. Additional land along the southern portion of the property was purchased by Shell in 1939. The general layout of the former bulk terminal during 1975 is shown in Figure 2.

Facilities at the former Shell bulk terminal during 1975 included 42 above-grade petroleum product storage and filter tanks, truck and rail car loading racks, warehouses, a barrel-storage slab, a dock used for product

transfer, a facility for heating high viscosity products, plus office, laboratory and garage buildings. Products stored at the former Shell bulk terminal included gasolines, diesel, kerosene, aviation gas, jet fuel, solvents, lube oils, fuel oils and asphalt.

Buried petroleum product pipelines have been used in the past by Shell to transfer asphalt, light and heavy fuel oils, aviation fuels, and marine diesel from the apron area to their tank farms. These pipelines are currently used by Shell to transfer marine diesel and heavy and light fuel oils between the apron area of Terminal 18 and the existing Shell tank farms.

Buried petroleum product pipelines were also used to transfer product within the former bulk terminal property. These lines were removed by the Port of Seattle in 1980. The locations of the existing and former buried product pipelines are shown in Figure 2.

The existing asphalt and fuel oil pipelines are equipped with heating cables to facilitate movement of these relatively viscous products. Asphalt product has solidified within the asphalt pipeline and this pipeline is no longer usable.

The former Shell bulk terminal property was purchased by the Port of Seattle during 1976 and demolished in 1980. The former Shell property and the adjacent land to the north and south are presently referred to as Terminal 18 and are currently used by Stevedoring Services of America (SSA) for container storage and transfer.

ADJACENT PROPERTY

The first record of development in the vicinity of the former Shell bulk terminal occurred prior to the formation of Harbor Island with the construction of a railroad line, supported on piles above the tidelands, along the alignment of Southwest Florida Street. A shingle mill, also supported on piles, operated between about 1895 and 1910 in the area north of the railroad alignment between Southwest Florida Street and Southwest Massachusetts Street (northwest of the former Shell bulk terminal at Terminal 18).

Development of the property immediately south of the former Shell bulk terminal began in 1918 with the construction of a shipping terminal by the East Waterway Dock and Warehouse Company (EWD&WC). The former EWD&WC facility was used primarily for bulk storage and transfer of non-petroleum oils (vegetable, fish and animal).

The Port of Seattle began operations at the site of the former EWD&WC facility in the 1940s. The majority of the former EWD&WC site is presently used for container storage and transfer. The western portion of the former EWD&WC site is currently used for bulk storage of tallow by Jacob Stearn & Sons, Inc.

Shell and ARCO petroleum tank farms are located west of the former Shell terminal (west of 11th Avenue Southwest). The southernmost existing Shell tank farm and the ARCO tank farm existed prior to 1940 based on review of aerial photographs.

Land north of the former Shell bulk terminal property remained relatively undeveloped until at least 1940. A 1940 aerial photograph shows that many small residences existed in the area at that time.

Later development on the land north of the former Shell tank farm was related to shipyard operations and included; machine, paint and steel fabricating shops: warehouses and garage, restaurant and office buildings. Land north of the former Shell tank farm is currently part of Terminal 18 and is used as a terminal for container storage and transfer.

SITE CONDITIONS

SURFACE CONDITIONS

The former Shell bulk terminal property is currently used for cargo container storage and transfer. The site is paved with asphaltic concrete and is relatively level with a surface elevation of about Elevation 17.5 feet (MLLW datum). Surface runoff is collected within storm drainage systems which drain to the East Duwamish Waterway. A concrete apron extends over the East Duwamish Waterway along the eastern portion of the terminal. The apron is used by SSA for loading/unloading container ships and by Shell Oil Company for transfer of petroleum products. Southwest 11th Street and railroad lines are located adjacent to the western site boundary. Future plans at the site include construction of an intermodal yard in the western portion of the site for shipment of containers by train.

SUBSURFACE SOIL CONDITIONS

Subsurface soil conditions were explored by drilling thirteen borings (MW-1 through MW-13) to depths of about 15 to 20 feet below the surface of

the asphaltic concrete pavement. The locations of Borings MW-1 through MW-13 are shown in Figures 2 and 4. Details of the field exploration program and the boring logs are given in Appendix A.

Additional information relating to subsurface conditions at and in the vicinity of the former Shell bulk plant is given in the following reports:

1. Twelker & Associates, Soils and Foundation Investigation for Proposed Reconstruction of Terminal 20 and Pier 19, Harbor Island, Seattle, Washington, prepared for Port of Seattle, August 31, 1973.
2. Norton Corrosion Limited, Inc., Corrosion Control Survey, Terminal 19/20, Buried Fuel Piping, Seattle, Washington, prepared for Port of Seattle, March 11, 1986.
3. Hart Crowser & Associates, Geochemical and Geotechnical Engineering Study, Terminal 18 - Intermodal Yard, Seattle, Washington, prepared for Port of Seattle, July 9, 1987.

The borings generally encountered medium dense to very dense, fine to coarse sand with gravel and/or fine to coarse gravel with sand from beneath the asphaltic concrete pavement to depths of 4 to 6 feet below grade. This soil appears to be imported fill that was placed to increase the surface elevation of the site after demolition of the former Shell bulk terminal.

The borings encountered loose to medium dense, fine to medium sand with a variable amount of silt beneath the surficial imported fill unit. The fine to medium sand unit contains occasional interbeds of silt and organic matter and extends downward to a depth of about 160 feet

(Elevation -140 MLLW) based on available reports. The upper 10 to 15 feet of the fine to medium sand unit appears to consist of fill placed by dredging during excavation of the East Duwamish Waterway and formation of Harbor Island.

Very dense sand, gravel and silt are found below the fine to medium sand unit (below Elevation -140 MLLW) based on available reports.

Borings MW-6, MW-8, MW-9 and MW-13 encountered sand with gravel and gravel with sand (imported fill) from beneath the pavement to depths of about 13 and 16 feet, respectively. Fine to medium sand was encountered below the imported fill in Borings MW-6, MW-9, and MW-13. The base of the imported fill was not encountered in Boring MW-8, which was completed at a depth of 15 feet. The eastern boundary of the site was extended about 20 feet eastward by installing a sheet pile bulkhead and placing imported fill during construction of the container terminal at Terminal 18. The sand and gravel fill encountered in Borings MW-6, MW-8, MW-9 and MW-13 appears to be related to construction of the eastward extension of the site boundary.

Boring MW-12 encountered gravel with sand to a depth of about 10.5 feet below grade. Boring MW-12 is located west of the area of the recent fill placement and the gravel with sand encountered at this location does not appear to be related to the eastward extension of the site.

The hydraulic conductivity of the uppermost portion of the fine to medium sand unit (dredge fill) is estimated to be about 0.006 feet per minute based on the grain size distribution of the soil. The hydraulic conductivity of the imported sand and gravel fill is estimated to be about 0.03 feet per minute based soil grain size characteristics.

GROUND WATER CONDITIONS

Monitor Wells MW-1 through MW-13 were installed in the thirteen borings completed during this study. Construction details for the wells and details of the field exploration program are given in Appendix A.

Monitor Well HC-2, located in the southwest corner of the former Shell bulk terminal, and Monitor Wells A-1 through A-5, located in the area of the current Shell tank truck loading rack, were installed by others prior to this study and were included in our field program to provide additional details relating to ground water conditions. The locations of the monitor wells are shown in Figure 4.

We measured the depth to the ground water table in the monitor wells several times, including two 12-hour intervals on February 6 (Wells MW-1 through MW-9, HC-1, and A-1 through A-5) and June 4, 1988 (Wells MW-1 through MW-12, HC-1, and A-1 through A-5). Fluid levels were also measured in Wells MW-7, MW-10, MW-11, MW-12 and MW-13 during a 48-hour interval between October 26 and October 28, 1988. The elevation of the surface of the East Duwamish Waterway was monitored during these periods to evaluate the relationship between tide height and ground water elevations. The ground water table was encountered at depths of about 6.5 to 10 feet below pavement grades at the time of our measurements. Plots

of the elevation of the ground water table in each monitor well and the elevation of the surface of the East Duwamish Waterway during the 12-hour periods on February 6 and June 4, 1988 are given in Appendix A.

The elevation of the ground water table beneath the site generally does not appear to respond to tide changes in the East Duwamish Waterway, with the exception of the extreme eastern portion of the site (adjacent to the waterway). The ground water elevation in Monitor Wells MW-6, MW-7, MW-9, MW-12 and MW-13 responded to tidal changes. The ground water level varied by about 0.25 to 0.5 feet in Monitor Well MW-7 in response to tidal fluctuations of about 7 and 12 feet in the East Duwamish Waterway on February 6 and June 4, 1988, respectively. The water level varied by 2.5 to 3 feet in Monitor Wells MW-6 and MW-9 on these dates. The elevation of the ground water table varied by about 2 feet in Monitor Well MW-12 on June 4, 1988. The elevation of the ground water table varied by about 3 feet in Monitor Well MW-13 in response to tidal fluctuation of about 6 feet on October 26, 1988. The lag time between peak water levels in the East Duwamish Waterway and the wells ranged from about 0.75 hours in Monitor Well MW-6 to about 1.75 hours in Monitor Well MW-9.

The approximate elevation of the ground water table in the monitor wells at about high tide, mid tide and low tide based on the February 6 and June 4, 1988 measurements are shown in Figures 5 through 10. Contours of the elevation of the ground water table based on the monitor well measurements are also shown in Figures 5 through 10.

The general direction of ground water flow beneath the former Shell Terminal appears to be eastward toward the East Duwamish Waterway during

periods of low to moderate tide, as shown in Figures 6, 7, 9 and 10. Ground water appears to flow from the East Duwamish Waterway toward the central portion of the site during periods of high tide, as shown in Figures 5 and 8.

The exchange of ground water with surface water in the East Duwamish Waterway appears to occur primarily beneath the northeastern and southeastern corners of the former Shell bulk terminal. The relatively high degree of hydraulic connection between the ground water aquifer and the East Duwamish Waterway in the northeastern and southeastern portions of the site is reflected by the response of the ground water table to tidal flux, as measured in Monitor Wells MW-6, MW-9, MW-12 and MW-13.

The direction of ground water flow beneath the eastern portion of the former Shell bulk terminal appears to be affected by the presence of the relatively permeable imported fill in this area and a timber bulkhead which formed the eastern site boundary prior to construction of the container facility at Terminal 18. During construction of the container facility, a sheet pile bulkhead was installed east of the timber bulkhead and imported fill was placed between the two bulkheads. The locations of the timber and sheet pile bulkheads are shown in Figures 5 through 10.

A review of aerial photographs and plans of the former Shell bulk terminal indicates that the timber bulkhead does not extend to the northeastern portion of the site (in the vicinity of Monitor Well MW-9). The absence of the timber bulkhead and presence of relatively more permeable imported fill appears to allow ground water and surface water to exchange more easily in the northeastern portion of the site.

Buried petroleum product pipelines pass through the timber bulkhead and the more recent sheet pile bulkhead in the southeastern portion of the site. The flow of ground water along the pipeline alignment and the presence of permeable imported fill may facilitate subsurface water exchange between East Duwamish Waterway and the southeastern portion of the site.

Monitor Well MW-8 is located between the timber bulkhead and sheet pile bulkhead in the area of a former ferry fueling slip. The elevation of the water surface in Monitor Well MW-8 did not respond significantly to tide changes in the East Duwamish Waterway. The lack of response suggests that the subsurface in the vicinity of Monitor Well MW-8 is hydraulically isolated from the regions near Monitor Wells MW-6, MW-9 and MW-13.

POTENTIAL SITE CONTAMINATION

GENERAL

Potential sources of soil and ground water contamination on Harbor Island include lead smelting, scrap metal yards, petroleum and non-petroleum oil terminals, metal processing facilities, and shipyard operations. Previous studies and remedial measures on Harbor Island have primarily dealt with airborne and surficial soil contamination by lead smelting and metal processing operations. Future studies by others will address known or suspected contamination by other hazardous materials. Systems to recover free (floating) petroleum product from the subsurface are currently operating at the existing Shell and Texaco bulk terminals on

Harbor Island. ARCO conducted subsurface explorations at their tank farm on the western side of Harbor Island during 1987. The results of the ARCO studies are not available.

Available data suggest that non-petroleum sources of contamination from off-site locations have had little environmental impact on the former Shell bulk terminal property. Analytical results for soil and ground water samples collected in 1987 by Hart-Crowser in the southwestern portion of the former Shell property and property northwest of Terminal 18 indicate insignificant subsurface contamination.

Past studies have indicated that a portion of the subsurface beneath the former Shell bulk terminal at Terminal 18 is contaminated by petroleum products. Petroleum-contaminated soil was noted on boring logs during a 1973 geotechnical study (Twelker & Assoc., 1973) and during a 1986 corrosion control study (Norton Corrosion Limited, 1986). Petroleum-contaminated soil was observed by the Port's representatives during demolition of the bulk terminal during 1980.

A system to recover free petroleum product from the subsurface in the eastern portion of the former bulk terminal was operated by Shell between May 1972 and January 1976. Information provided by Shell suggests that approximately 155,000 gallons of product was recovered during this time interval. The extent of the free petroleum product plume beneath the former Shell bulk terminal during January 1975 is shown in Figure 2. Information related to the extent of the free product plume during January 1976 (when recovery was terminated) is not available.

A discrete source of the free petroleum product beneath the former Shell bulk terminal during the 1970s is not known. A search of Ecology's files pertaining to Shell Oil Company revealed little information about activities prior to 1980, other than indications that barrel storage operations were improved by constructing a concrete storage slab during the early 1970s.

A thin layer of free petroleum product has been observed within two concrete vaults which extend below the ground water table in the southeastern portion of the former Shell bulk terminal. These concrete vaults serve as valve pits for the active petroleum product pipelines which are located beneath the site. These pipelines are contained within a concrete trough which is lined with polypropylene. The source of the petroleum product in the southeastern valve pits appears to have been leaks in the pipelines due to corrosion. It appears that product which has leaked from the pipeline has flowed along the pipeline alignment (and concrete trough) to the valve pits. The water and free product which accumulates in the southeastern valve pits at the site is pumped to an oil/water separator prior to discharge to the East Duwamish Waterway.

A second pair of valve pits are located in the east-central portion of the site. Free product does not appear to seep into the east-central valve pits.

Ecology's files indicate that spills of 12,200 and 9,000 gallons of gasoline occurred during 1981 and 1982, respectively, at the existing Shell tank farms, located west of 11th Avenue Southwest. Data from Ecology's files also indicate that a plume of free petroleum product is

present beneath the existing Shell tank farms and that about 200 gallons of free petroleum product was recovered from the subsurface during a period of about one month during early 1987.

SUBSURFACE CONTAMINATION

General: Explorations for potential subsurface fuel-related contamination at the former Shell bulk terminal during our studies have included:

A. Physical and visual examination of soil samples for the presence of petroleum odor and/or sheen in the samples.

B. Measuring the air space in the monitor well casings for hydrocarbon (combustible) vapors by using a "TLV Sniffer" combustible gas indicator.

C. Sampling the water table interface in each well with a transparent bailer for the presence of free (floating) petroleum product.

D. Obtaining a sample of free petroleum product from Monitor Wells MW-7 and MW-12 and analyzing the samples for product type, API gravity, and flash point.

E. Field measurement of pH, temperature and electrical conductivity of ground water from the monitor wells.

F. Chemical analysis of ground water samples from the monitor wells for petroleum-related contaminants. Ground water samples collected from the monitor wells were analyzed by EPA Method 602 for benzene, toluene, xylenes (m,p,o), chlorobenzene, ethylbenzene and dichlorobenzenes. The ground water samples

were also analyzed for petroleum hydrocarbons by EPA Method 418.1 and for total dissolved lead and dissolved organic lead by EPA Method 7421.

Details of the field exploration and sampling program are given in Appendix A. Pertinent subsurface contamination data are summarized in Table 1. Laboratory reports for the ground water samples are given in Appendix B.

Petroleum-like Odors, Sheen and Hydrocarbon Vapors: Petroleum-like odors were detected in soil samples from Borings MW-1 through MW-8 and MW-10 through MW-13. Petroleum-like odors were not detected in soil samples from Boring MW-9.

Petroleum-like sheens were observed in soil samples from Borings MW-3, MW-7, MW-10 and MW-11. Petroleum-like sheens were not observed in soil samples from the remaining borings.

Hydrocarbon (combustible) vapors were detected within the well casings at significant concentrations (>400 ppm) in Monitor Wells MW-1 through MW-5, MW-7, MW-10 through MW-12 and MW-A1 through MW-A5 on February 6 and/or June 6, 1988. Hydrocarbon (combustible) vapor measurements are summarized in Table 1.

Free Petroleum Product: Free (floating) petroleum product was detected in Monitor Wells MW-3, MW-7, MW-12, MW-A3 and MW-A4. The approximate areal extent of the plume of free product within Terminal 18 is shown on Figure 11. The thickness of free product measured in these wells on February 6, June 4, 1988 and October 26 through October 28, 1988 is summarized below.

Monitor Well	Free Product Thickness (Feet)		
	2/6/88	6/4/88	10/26/88 to 10/28/88
MW-3	0	0	0.75
MW-7	0.91 to 1.11	0.35 to 0.51	0.71
MW-12	not installed	0.05 to 1.56	0.37 to 0.91
MW-A3	0.09 to 0.12	0.09 to 0.10	not measured
MW-A4	0 to 0.03	0.01 to 0.04	not measured

Variation in the thickness of free product within Monitor Wells MW-7 and MW-12 generally appears to be related to tide height. The greatest thickness of free product within Monitor Wells MW-7 and MW-12 generally occurs at the time of lowest measured water table elevation.

Free product was not detected in Monitor Well MW-3 during our February 1988 or June 1988 measurements. Free product was detected in Monitor Well MW-3 during the October 1988 round of measurements. The water table elevation in Monitor Well MW-3 decreased by about 0.67 feet between the February 1988 and October 1988 measurements, apparently as a result of seasonal precipitation patterns. The presence of free product in Monitor Well MW-3 during the October measurements may be related to the lower water table elevation that was measured at that time.

Analysis of samples of free product from Monitor Wells MW-7 and MW-12 indicates that the product consists of a mixture of about 10 percent gasoline and 90 percent diesel fuel with a flash point of 82 to 84 degrees Fahrenheit and an API Gravity of 33.8 to 35.5.

Ground Water Quality: Ground water samples were collected on January 30, 1988 for analysis by EPA Methods 602 and 7421 from Monitor

Wells MW-1 through MW-6, MW-8 and MW-9. Ground water samples were collected for analysis by EPA Method 418.1 from Monitor Wells MW-1 through MW-6 and MW-8 through MW-11 on May 14, 1988. Ground water samples were collected for analysis by EPA Methods 602 and 7421 from Monitor Wells MW-10 and MW-11 on May 14, 1988. Ground water samples were collected from Monitor Well MW-13 on October 28, 1988 for analysis by EPA Method 602 and 418.1. Monitor wells near the East Duwamish Waterway were sampled during periods of low tide height. Ground water samples were not collected from Monitor Wells MW-7 and MW-12 due to the presence of free petroleum product in these wells. (Free product was detected in Monitor Well MW-3 about nine months after the ground water sample was collected from this well).

A petroleum-like sheen was observed on the surface of ground water bailed from Monitor Wells MW-1 through MW-6, MW-10, MW-11, and MW-13.

The ground water samples were analyzed for the presence of benzene, toluene, xylenes, ethylbenzene, chlorobenzene, dichlorobenzene, petroleum hydrocarbons, dissolved organic lead and dissolved total lead. Benzene, ethylbenzene, toluene and xylenes (BETX) are contaminants that are related primarily to gasoline products but also may be found at low concentrations in other petroleum fuel products. The petroleum hydrocarbon analysis generally detects compounds related to diesel fuel and "heavier" petroleum products. Chlorobenzene and dichlorobenzenes are generally associated with solvents and pesticides. Lead originates from many sources including some fuel products. Results of the laboratory analyses are summarized in Table 1 and shown on Figure 12.

Chlorobenzene, dichlorobenzene and dissolved organic lead were not detected in the ground water samples from the site. The concentration of total dissolved lead in ground water samples from the site was below detection limits with the exception of the sample from Monitor Well MW-1. Total dissolved lead was detected in the ground water sample from Monitor Well MW-1 at a concentration of 0.004 ppm, much lower than the current drinking water quality standard for lead (0.05 ppm).

The analytical results indicate that BETX was either nondetectable or at concentrations below current recommended (or proposed) drinking water quality standards in ground water samples from Monitor Wells MW-1, MW-2, MW-4 through MW-6, MW-8, MW-9 and MW-13.

The concentrations of benzene in the ground water samples from Monitor Wells MW-3, MW-10 and MW-11 (350 ppb, 470 ppb and 2500 ppb, respectively) exceed the recommended drinking water quality standard for benzene (5 ppb). The concentration of benzene in the ground water sample from Monitor Well MW-11 exceeds the chronic exposure criteria for marine aquatic life (700 ppb) but is less than the acute exposure criteria for marine aquatic life (5100 ppb). Toluene, xylenes and/or ethylbenzene were detected in the ground water samples from Monitor Wells MW-3, MW-10, MW-11 and MW-13 at concentrations less than the applicable drinking water quality standards.

Petroleum hydrocarbons were detected in ground water from Monitor Wells MW-10, MW-11, and MW-13 at concentrations of 20.3 ppm, 31.3 ppm, and 62 ppm, respectively. The surface water discharge limit for petroleum hydrocarbons is generally established at 15 ppm. Petroleum hydrocarbons

were detected in ground water from the Monitor Wells MW-1 through MW-5, MW-8 and MW-9 at concentrations generally less than 1.0 ppm. Petroleum hydrocarbons were detected at a concentration of 0.53 ppm in the lab blank suggesting that the low concentrations detected in ground water from these wells may be related to laboratory contamination.

Ground water from Monitor Well HC-2 was sampled during April 1987 by Hart-Crowser & Associates. Dissolved fuel-related contaminants including benzene, toluene, xylenes and ethylbenzene were not detected during the April 1987 analysis of the ground water from Monitor Well HC-2.

Ground water temperature, pH and conductivity were measured at time of ground water sample collection on January 30 and May 14, 1988. Field ground water quality measurements are summarized in Table 2. Ground water temperature ranged from about 10 to 16 degrees centigrade, with the warmer temperatures measured in May as compared to January. The pH of the ground water ranged from about 5.9 to 7.9. The conductivity of the ground water ranged from about 170 to >19,900 umhos/cm. Ground water beneath the site is generally brackish near the East Duwamish Waterway, slightly brackish in the central portion of the site, and fresh near the western boundary of Terminal 18.

DISCUSSION AND RECOMMENDATIONS

FREE PETROLEUM PRODUCT

General: Free (floating) petroleum product was detected in Monitor Wells MW-3, MW-7 and MW-12, located in the central and southeastern portions of the former Shell bulk terminal. Information provided by Shell

indicates that a plume of free product was located in the area of Monitor Wells MW-7 and MW-12 during 1975. The location of the plume of free product during 1975 is shown in Figure 2.

We understand that the pipelines at the site have not been used to transfer gasoline products since the Shell terminal was demolished. About 10 percent of the plume of petroleum product is composed of gasoline, suggesting that at least a portion of the product encountered at the site was present prior to demolition of the terminal.

Remediation: We recommend that future remedial actions at the former Shell bulk terminal include implementation of a program to recover free petroleum product from the subsurface. A test pumping program was conducted in Monitor Well MW-7 to evaluate if the existing monitor wells could be used effectively for the recovery of free product. The program consisted of removing water and product from Monitor Well MW-7 by pumping with vacuum trucks for a period of 48-hours. Water was pumped from Monitor Well MW-7 at an average rate of about 1.4 gallons per minute (a total of about 4000 gallons) with a drawdown in the water level of about 4.5 feet. An insignificant volume of free product was recovered from Monitor Well MW-7 during the pumping test (only a sheen was observed on the surface of the water which accumulated in the vacuum truck tank). Fluid levels were monitored in Monitor Wells MW-10, MW-11, MW-12 and MW-13 (located near Monitor Well MW-7) during the pumping test. Fluid levels in these wells did not appear to be affected by pumping from Monitor Well MW-7.

Based on the results of the pumping test, we recommend against using the existing monitor wells for recovery of free product in the region of Monitor Wells MW-7 and MW-12. Instead, we recommend that a large diameter recovery well be installed in the area between Monitor Wells MW-7 and MW-12, located as shown in Figure 11, for the recovery of free product in this region. The design of this recovery well is based on the recovery systems that are currently operating at Terminal 30. Schematic plans for the recovery system are shown in Figure 13. We estimate that the cost of installing the recovery system will be about $50,000 with operating/ monitoring costs of about $3,000 per month. We estimate that the recovery system will operate for a period of at least 2 years.

A second recovery system may be needed in the region of Monitor Well MW-3. Free product was detected in this well for the first time during our last round of measurements on October 28, 1988. We recommend that the second recovery system be installed if free product continues to be detected at Monitor Well MW-3 after 6 months of operation of the proposed recovery system near Monitor Wells MW-7 and MW-12. Costs for the second system will be similar to costs for the proposed recovery system near Monitor Wells MW-7 and MW-12.

GROUND WATER CONTAMINATION

General: The concentrations of dissolved petroleum-related contaminants (BETX and petroleum hydrocarbons), dissolved organic lead and total dissolved lead in ground water from Monitor Wells MW-1, MW-2, MW-4,

MW-5, MW-6, MW-8, and MW-9 were generally nondetectable or less than the recommended (or proposed) drinking water quality standards for these contaminants.

Elevated concentrations of benzene were detected in ground water from Monitor Wells MW-3, MW-10 and MW-11. Monitor Wells MW-7 and MW-12 are located near the East Duwamish Waterway and free product has been detected in these wells. Ground water samples were not collected from these wells because of the presence of free product. We expect that ground water in the vicinity of Monitor Wells MW-7 and MW-12 also contains elevated concentrations of dissolved petroleum-related contaminants.

Ground water appears to flow to the East Duwamish Waterway primarily from beneath the northeastern and southeastern corners of the site (near Monitor Wells MW-6 and MW-9), although a limited amount of seepage of ground water in an eastward direction from beneath the plume (toward Monitor Well MW-13) may occur during periods of low tide. Benzene was not detected in ground water from Monitor Wells MW-6, MW-8, MW-9 and MW-13, located near the East Duwamish Waterway and downgradient of Monitor Wells MW-3, MW-7, MW-10, MW-11 and MW-12. It is possible that the concentrations of benzene detected in ground water from Monitor Wells MW-3, MW-10, MW-11 and from beneath the free product plume decline to nondetectable levels through dilution and/or biodegradation as ground water flows eastward and mixes with brackish water before discharging into the East Duwamish Waterway.

An elevated level of TPH was detected in ground water from Monitor Well MW-13, located east of the free product plume and the timber

bulkhead. The presence of TPH in ground water from Monitor Well MW-13 suggests that the "heavier" dissolved components of the free product may be slowly migrating through the timber bulkhead in this region. TPH generally degrades less rapidly than BETX and ground water contaminated by TPH may be migrating to the East Duwamish Waterway in the vicinity of Monitor Well MW-13.

Although we expect that ground water in the region of the free product plume is contaminated by components of petroleum products, the contaminated ground water does not appear to represent an imminent threat to public health or the environment. As described previously, the exchange of ground water with surface water in the East Duwamish Waterway appears to occur primarily from beneath the southeastern and northeastern corners of the site (in the vicinity of Monitor Wells MW-6 and MW-9, respectively), areas in which little or no petroleum-related contamination has been detected in ground water.

Remediation: We estimate that contaminated ground water will be pumped from the recovery well(s) at a rate of about 4 gpm per well during the proposed free product recovery program. We recommend that this water be routed through an oil/water separator prior to discharge to the METRO sewer system. We estimate that the cost of installing the oil/water separator will be about $5,000 with the cost of water disposal at about $4,500 per well per year.

We recommend that the possible need for additional treatment of ground water (in addition to the water pumped during the proposed free product recovery program) be evaluated after completion of the proposed free product recovery program.

ADDITIONAL MONITORING

We recommend that the on-site monitor wells be measured monthly to monitor future trends in water levels and product thickness. We further recommend that ground water samples be collected from Monitor Wells MW-6, MW-8, MW-9, and MW-13 on a quarterly basis (4 times per year) and analyzed for the presence of petroleum-related contaminants to establish a data base for future evaluation.

OIL/WATER SEPARATORS

Four concrete vaults which are located near the East Duwamish Waterway are used as valve pits for the petroleum product pipelines. Ground water which accumulates in the vaults is pumped to two separate oil/water separators. Water from the oil/water separators is discharged to the East Duwamish Waterway through the storm water system. Free product has accumulated in the southeastern valve pit in the past apparently as a result of pipeline leaks.

We recommend that the volume of free product that accumulates in the southeastern oil/water separator be monitored on a weekly basis to evaluate the rate of product accumulation, to detect potential future leaks in the pipelines, and to determine when the oil/water separator is at capacity with respect to the stored volume of free product.

LIMITATIONS

We have prepared this report for use by the Port of Seattle in the evaluation of subsurface petroleum-related contamination at the former Shell bulk terminal at Terminal 18. The information contained herein is not applicable to other sites.

Our conclusions are based on limited subsurface data and are subject to modification based on the results of future monitoring and/or additional explorations at the site.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No other conditions, express or implied, should be understood.

- o O o -

We appreciate the opportunity to be of service. Please call if you have any questions regarding our report.

Respectfully submitted,

GeoEngineers, Inc.

John H. Biggane
Project Manager

James A. Miller
Principal

JHB:JAM:cs

TABLE 1

SUMMARY OF GROUND WATER ANALYTICAL DATA

Monitor Well	Benzene (ppb)	Toluene (ppb)	Ethyl-benzene (ppb)	Total Xylenes (ppb)(1)	Petroleum Hydrocarbons (ppm)	Dissolved Organic Lead (ppm)	Dissolved Total Lead (ppm)	Hydrocarbon Vapor(2) Concentration (ppm) 2/6/88	Hydrocarbon Vapor(2) Concentration (ppm) 6/4/88	Petroleum Odor Detected During Drilling	Comments
MW-1	<0.5	0.71	<0.5	<0.5	0.27	<0.01	0.004	6800	40	Yes	Slight sheen on water
MW-2	<0.5	0.91	<0.5	<0.5	0.30	<0.01	<0.002	>10,000	54	Yes	Slight sheen on water
MW-3	350	7.1	0.90	72	1.9	<0.01	<0.002	>10,000	>10,000	Yes	Slight sheen on water
MW-4	<0.5	<0.5	<0.5	54	0.13	<0.01	<0.002	>10,000	>10,000	Yes	Slight sheen on water
MW-5	<0.5	1.2	<0.5	0.98	0.40	<0.01	<0.002	9000	>10,000	Yes	Dark sheen on water
MW-6	<0.5	0.76	1.3	1.89	--	<0.01	<0.008	60	--	Yes	Dark sheen on water
MW-7	--	--	--	--	--	--	--	>10,000	>10,000	Yes	Free product present on water
MW-8	<0.5	<0.5	<0.5	<0.5	<0.05	<0.01	<0.002	30	--	Yes	No sheen
MW-9	<0.5	<0.5	<0.5	1.2	0.07	<0.01	<0.008	340	140	No	No sheen
MW-10	470	29	<12.5	31	20.3	<0.01	<0.002	--	>10,000	Yes	Sheen on water
MW-11	2500	48	150	423	31.3	<0.01	<0.002	--	>10,000	Yes	Sheen on water
MW-12	--	--	--	--	--	--	--	--	>10,000	Yes	Free product present on water
MW-13	<5	6.5	<5	9.8	62	--	--	--	--	Yes	Sheen on water
HC-2	<1.	<1.	<1.	<1.	--	--	<0.01	40	240	No	
MW-A1	--	--	--	--	--	--	--	2400	>10,000	--	
MW-A2	--	--	--	--	--	--	--	>10,000	>10,000	--	
MW-A3	--	--	--	--	--	--	--	>10,000	>10,000	--	Free product present on water
MW-A4	--	--	--	--	--	--	--	>10,000	>10,000	--	Free product present on water
MW-A5	--	--	--	--	--	--	--	>10,000	>10,000	--	

Notes: (1) Sum of o, m & p xylenes.

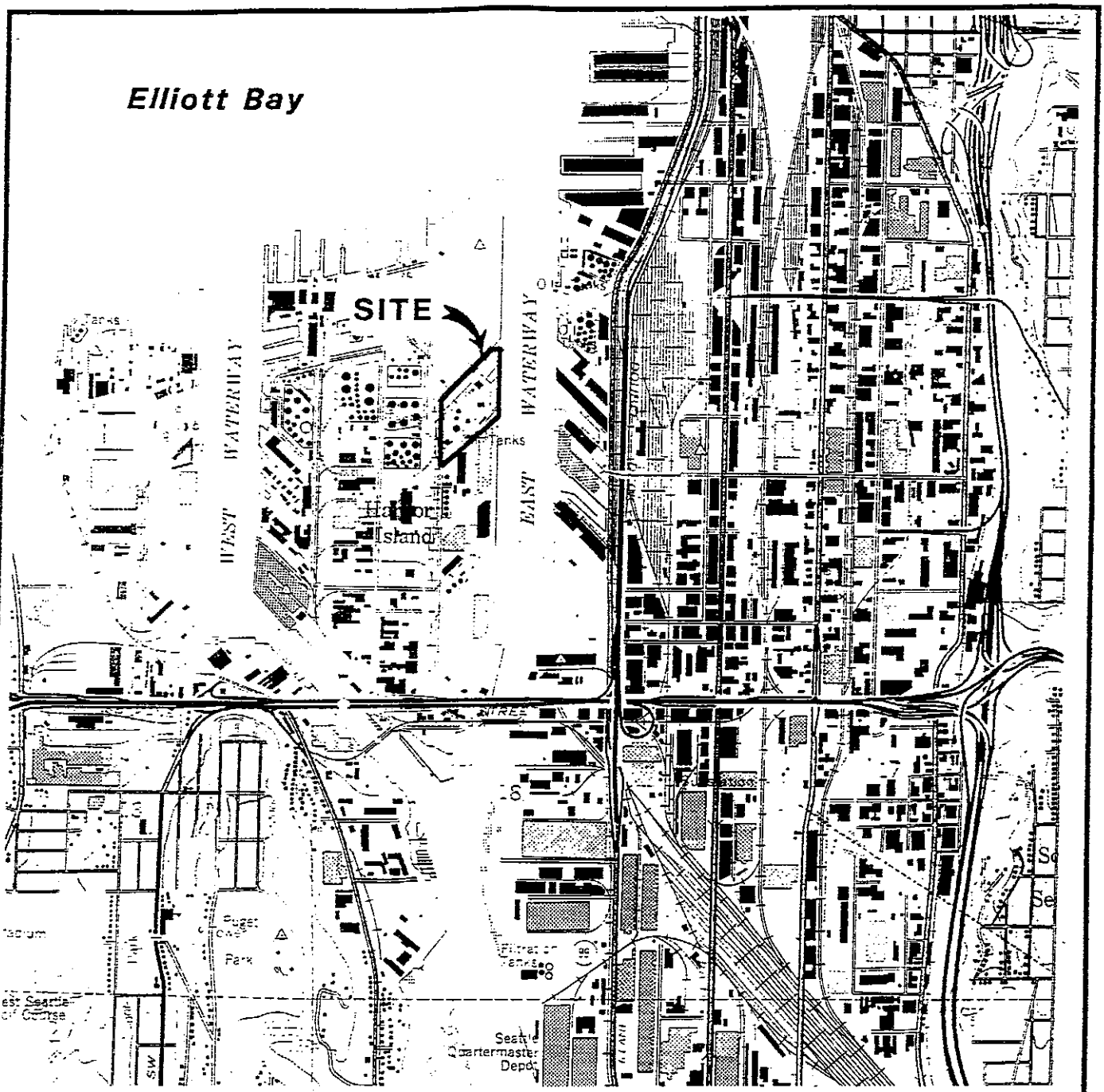
(2) Measurements obtained in monitor wells using Bacharach TLV Sniffer calibrated to hexane (110 ppm = 1% LEL of hexane).

-- = Not sampled or tested.

TABLE 2

SUMMARY OF FIELD GROUND WATER QUALITY MEASUREMENTS

Monitor Well	Temperature (°C)		Conductivity (umhos/cm)		pH	
	2/6/88	6/4/88	2/6/88	6/4/88	2/6/88	6/4/88
MW-1	10	13.3	220	330	7.3	7.0
MW-2	11.5	13.9	185	170	6.7	6.5
MW-3	11.5	13.3	570	470	6.0	7.0
MW-4	15	16.1	1060	760	6.2	6.6
MW-5	12	13.9	1940	1700	6.2	6.3
MW-6	14	—	1320	—	6.6	—
—	—	—	—	—	—	—
MW-8	10	15.6	2030	1070	5.9	6.7
MW-9	10	12.2	1330	>19,900	7.6	7.9
MW-10	—	14.4	—	1120	—	6.4
MW-11	—	14.4	—	950	—	6.2
MW-12	—	—	—	—	—	—



REFERENCE: USGS 7.5' TOPOGRAPHIC QUADRANGLE MAP "SEATTLE SOUTH, WASH."

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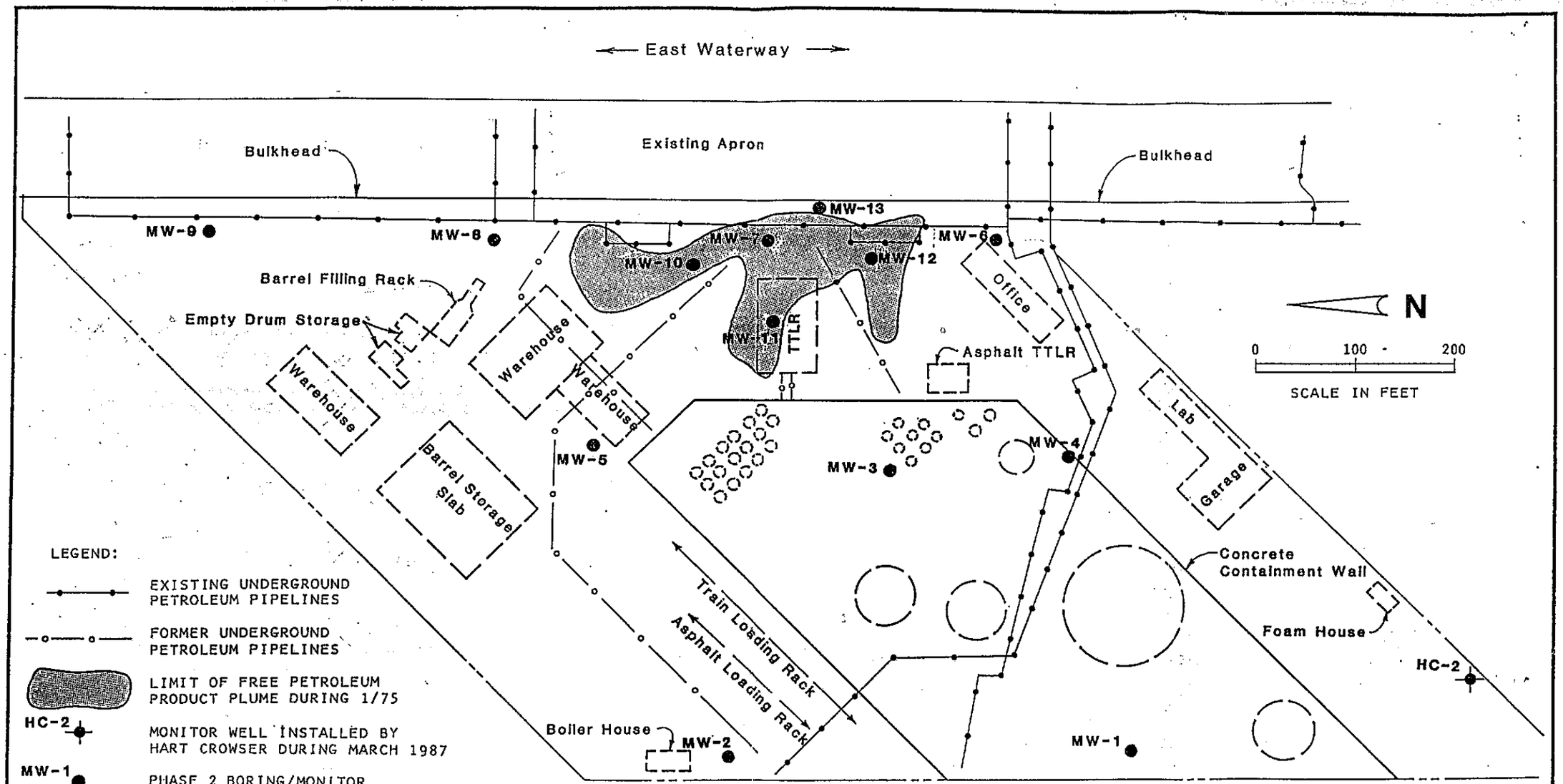
VICINITY MAP

FIGURE 1

0303-24-2 JHB:KN 10-15-01



REFERENCE: PLAN ENTITLED "SHELL PIPELINE OIL MEASUREMENT AND CONTROL" DATED 1/75.

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GENERAL LAYOUT OF FORMER SHELL BULK TERMINAL

FIGURE 2

HI-SHELL000705

← East Waterway →

N

Shipyard Activities
(1940 TO LATE 1960'S)

Port of Seattle, T-18
(LATE 1960'S TO PRESENT)

Shell Oil Company
Tank Farm
(1924 TO 1970'S)

Port of Seattle, T-18
(1970'S TO PRESENT)

East Waterway Warehouse
& Dock Company
(1918 TO 1940'S)

Port of Seattle, T-18
(1940'S TO PRESENT)

(VACATED) **11th Avenue Southwest**

S. W. Massachusetts St.

Burlington Northern
(EARLY 1960'S TO PRESENT)

Florida Street

Arco
Tank Farm
(<1940 TO PRESENT)

Olympic Pipeline Company

Shell Oil Company
Tank Farm
(>1940 TO PRESENT)

Shell Oil
Company
Tank Farm
(<1940 TO PRESENT)

Lander Street (VACATED)

Leckenby Structural
Steel Co.
(>1940 TO PRESENT)

United States
Gypsum Company
(>1940 TO PRESENT)

0 100 200 300 400 500

SCALE IN FEET

GeoEngineers Incorporated

CURRENT AND HISTORIC LAND USE

FIGURE 3

0505-24-4 JHB:KKI 10-14-87

HI-SHELL000706

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9

MW-8

MW-7

MW-13

MW-6

MW-10

MW-12

MW-11

Former Location of Shell Terminal

MW-5

MW-3

MW-4

Tallow Storage Area

HC-2

MW-2

MW-1

N

11th Avenue S. W.

S. W. Florida St.

0 200 400

SCALE IN FEET

EXPLANATION:

MW-1 ● LOCATION OF BORING/MONITOR WELL

ARCO Tank Yard

OPLC Terminal

Shell Tank Yard

Shell Tank Yard

MW-A4

MW-A5

Shell Tank Truck Loading Facility

MW-A1

TTLR

MW-A2

MW-A3

13th Avenue S. W.

Texaco Tank Yard

S. W. Lander St.

0303-24-4 JHB:KKT 2-1-88

GeoEngineers

GENERAL SITE PLAN

FIGURE 4

HI-SHELL000707

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 9.59

MW-8 8.95

MW-7 8.93

MW-6 10.40

9.5

9.0

10.0

9.5

Former Location of Shell Terminal

MW-5 9.43

MW-3 9.39

MW-4 9.40

9.5

9.5

10.0

HC-2 9.44

Tallow Storage Area

MW-2 10.35

MW-1 10.14

N

11th Avenue S. W.

0 200 400

SCALE IN FEET

S. W. Florida St.

ARCO Tank Yard

Shell Tank Yard

OPLC Terminal

Shell Tank Yard

MW-A4 8.54

MW-A5 8.52

MW-A1 8.56

MW-A2 8.56

TTLR

MW-A3 8.53

Shell Tank Truck Loading Facility

13th Avenue S. W.

S. W. Lander St.

Texaco Tank Yard

EXPLANATION:

GENERAL DIRECTION OF GROUND WATER FLOW

MW-7 8.93 MONITOR WELL LOCATION
APPROXIMATE GROUND WATER TABLE ELEVATION ON 2/6/88 AT 0715 HRS.

10.0 GROUND WATER TABLE CONTOUR . BASED ON 2/6/88 MONITOR WELL MEASUREMENTS

LOW TIDE OF 1.2 FEET AT 0029 HRS. ON 2/6/88
HIGH TIDE OF 11.9 FEET AT 0715 HRS. ON 2/6/88
LOW TIDE OF 4.2 FEET AT 1325 HRS. ON 2/6/88
HIGH TIDE OF 9.3 FEET AT 1853 HRS. ON 2/6/88

GeoEngineers Incorporated

GROUND WATER TABLE CONTOUR MAP
FEBRUARY 6, 1988 AT 0715 HRS. (HIGH TIDE)

FIGURE 5

0303-24-4 JHB:KKT 2-11-88

HI-SHELL000708

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 8.10

MW-8 8.96

MW-7 8.89

MW-6 7.41

9.0

8.5

8.0

8.5

Former Location of Shell Terminal

MW-5 9.42

MW-3 9.44

MW-4 9.40

9.5

9.5

10.0

HC-2 9.43

Tallow Storage Area

MW-2 10.34

MW-1 10.12

N

11th Avenue S. W.

0 200 400

SCALE IN FEET

S. W. Florida St.

ARCO Tank Yard

Shell Tank Yard

OPLC Terminal

Shell Tank Yard

MW-A4 8.56

MW-A5 8.52

MW-A1 8.56

MW-A2 8.55

TTLR

MW-A3 8.53

Shell Tank Truck Loading Facility

13th Avenue S. W.

S. W. Lander St.

Texaco Tank Yard

EXPLANATION:

GENERAL DIRECTION OF GROUND WATER FLOW

MW-7 8.89 MONITOR WELL LOCATION APPROXIMATE GROUND WATER TABLE ELEVATION ON 2/6/88 AT 1325 HRS.

10.0 GROUND WATER TABLE CONTOUR BASED ON 2/6/88 MONITOR WELL MEASUREMENTS

LOW TIDE OF 1.2 FEET AT 0029 HRS. ON 2/6/88
HIGH TIDE OF 11.9 FEET AT 0715 HRS. ON 2/6/88
LOW TIDE OF 4.2 FEET AT 1325 HRS. ON 2/6/88
HIGH TIDE OF 9.3 FEET AT 1853 HRS. ON 2/6/88

GeoEngineers Incorporated

GROUND WATER TABLE CONTOUR MAP FEBRUARY 6, 1988 AT 1325 HRS. (LOW TIDE)

FIGURE 6

0303-24-4 JHB:KKT 2-11-88

HI-SHELL000709

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 8.93

MW-8 8.97

MW-7 8.97

MW-6 8.70

9.0

Former Location of Shell Terminal

MW-5 9.43

MW-3 9.41

MW-4 9.39

9.5

9.5

10.0

HC-2 9.47

Tallow Storage Area

MW-2 10.25

MW-1 10.14

N

11th Avenue S. W.

S. W. Florida St.

0 200 400

SCALE IN FEET

EXPLANATION:

GENERAL DIRECTION OF GROUND WATER FLOW

MW-7 8.97 MONITOR WELL LOCATION
APPROXIMATE GROUND WATER TABLE ELEVATION ON 2/6/88 AT 1030 HRS.

10.0 GROUND WATER TABLE CONTOUR BASED ON 2/6/88 MONITOR WELL MEASUREMENTS

ARCO Tank Yard

Shell Tank Yard

OPLC Terminal

Shell Tank Yard

MW-A4 8.54

MW-A5 8.52

MW-A1 8.55

MW-A2 8.55

TTLR

MW-A3 8.53

Shell Tank Truck Loading Facility

13th Avenue S. W.

S. W. Lander St.

Texaco Tank Yard

LOW TIDE OF 1.2 FEET AT 0029 HRS. ON 2/6/88
HIGH TIDE OF 11.9 FEET AT 0715 HRS. ON 2/6/88
LOW TIDE OF 4.2 FEET AT 1325 HRS. ON 2/6/88
HIGH TIDE OF 9.3 FEET AT 1853 HRS. ON 2/6/88

GeoEngineers Incorporated

GROUND WATER TABLE CONTOUR MAP FEBRUARY 6, 1988 AT 1030 HRS. (MID TIDE)

FIGURE 7

0303-24-4 JHB KKT 2-11-88

HI-SHELL000710

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 9.02

MW-8 NA

MW-7 9.02

MW-6 NA

MW-10 8.99

MW-11 8.93

MW-12 9.05

Former Location of Shell Terminal

MW-5 9.24

MW-3 9.20

MW-4 9.18

9.5

9.5

Tallow Storage Area

HC-2 9.14

MW-2 9.93

MW-1 9.70

N

11th Avenue S. W.

S. W. Florida St.

0 200 400

SCALE IN FEET

EXPLANATION:

GENERAL DIRECTION OF GROUND WATER FLOW

MW-7 9.02 MONITOR WELL LOCATION
APPROXIMATE GROUND WATER TABLE ELEVATION ON 6/4/88 AT 0701 HRS:

9.0 GROUND WATER TABLE CONTOUR BASED ON 6/4/88 MONITOR WELL MEASUREMENTS

NA NOT ACCESSIBLE ON 6/4/88

LOW TIDE OF 7.6 FEET AT 0251 HRS. ON 6/4/88
HIGH TIDE OF 9.7 FEET AT 0701 HRS. ON 6/4/88
LOW TIDE OF -2.2 FEET AT 1430 HRS. ON 6/4/88
HIGH TIDE OF 12.4 FEET AT 2212 HRS. ON 6/4/88

ARCO Tank Yard

Shell Tank Yard

OPLC Terminal

Shell Tank Yard

MW-A4 8.30

MW-A5 8.59

Shell Tank Truck Loading Facility

TTLR

MW-A1 8.43

MW-A2 8.43

MW-A3 8.38

13th Avenue S. W.

S. W. Lander St.

Texaco Tank Yard

0303-24-4 JHB KKT 7-6-88

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GROUND WATER TABLE CONTOUR MAP JUNE 4, 1988 AT 0701 HRS.(HIGH TIDE)

FIGURE 8

HI-SHELL000711

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 8.73

MW-8 NA

MW-7 8.95

MW-6 NA

MW-10 8.94

MW-12 8.90

MW-11 8.95

9.0

9.0

Former Location of Shell Terminal

MW-5 9.24

MW-3 9.19

MW-4 9.18

9.5

9.5

HC-2 9.12

Tallow Storage Area

MW-2 9.92

MW-1 9.72

N

11th Avenue S. W.

0 200 400

SCALE IN FEET

S. W. Florida St.

ARCO Tank Yard

Shell Tank Yard

OPLC Terminal

Shell Tank Yard

MW-A4 8.30

MW-A5 8.59

TTLR

MW-A1 8.43

MW-A2 8.43

MW-A3 8.37

Shell Tank Truck Loading Facility

13th Avenue S. W.

S. W. Lander St.

Texaco Tank Yard

EXPLANATION:

GENERAL DIRECTION OF GROUND WATER FLOW

MW-7 8.95 MONITOR WELL LOCATION
APPROXIMATE GROUND WATER TABLE ELEVATION ON 6/4/88 AT 1045 HRS.

90 GROUND WATER TABLE CONTOUR BASED ON 6/4/88 MONITOR WELL MEASUREMENTS

NA NOT ACCESSIBLE ON 6/4/88

LOW TIDE OF 7.6 FEET AT 0251 HRS. ON 6/4/88
HIGH TIDE OF 9.7 FEET AT 0701 HRS. ON 6/4/88
LOW TIDE OF -2.2 FEET AT 1430 HRS. ON 6/4/88
HIGH TIDE OF 12.4 FEET AT 2212 HRS. ON 6/4/88

0303-24-4 JHB:KKT 7-6-88

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GROUND WATER TABLE CONTOUR MAP JUNE 4, 1988 AT 1045 HRS. (MID TIDE)

FIGURE 9

HI-SHELL000712

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 7.69

MW-8 NA

MW-7 8.22

MW-10 8.95

MW-12 7.18

MW-6 NA

MW-11 8.91

8.0

9.0

7.0

8.0

8.0

MW-5 9.23

MW-3 9.20

MW-4 9.18

Former Location of Shell Terminal

9.5

9.5

HC-2 9.12

Tallow Storage Area

MW-2 9.93

MW-1 9.72

N

11th Avenue S. W.

0 200 400

SCALE IN FEET

S. W. Florida St.

ARCO Tank Yard

Shell Tank Yard

OPLC Terminal

Shell Tank Yard

MW-A4 8.27

MW-A5 8.41

MW-A1 8.35

MW-A2 8.35

TTLR

Shell Tank Truck Loading Facility

MW-A3 8.37

13th Avenue S. W.

S. W. Lander St.

Texaco Tank Yard

EXPLANATION:

GENERAL DIRECTION OF GROUND WATER FLOW

MW-7 8.22 MONITOR WELL LOCATION
APPROXIMATE GROUND WATER TABLE ELEVATION ON 6/4/88 AT 1430 HRS.

9.0 GROUND WATER TABLE CONTOUR BASED ON 6/4/88 MONITOR WELL MEASUREMENTS

NA NOT ACCESSIBLE ON 6/4/88

LOW TIDE OF 7.6 FEET AT 0251 HRS. ON 6/4/88
HIGH TIDE OF 9.7 FEET AT 0701 HRS. ON 6/4/88
LOW TIDE OF -2.2 FEET AT 1430 HRS. ON 6/4/88
HIGH TIDE OF 12.4 FEET AT 2212 HRS. ON 6/4/88

0303-24-4 JHB:KKT 7-6-88

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GROUND WATER TABLE CONTOUR MAP JUNE 4, 1988 AT 1430 HRS.(LOW TIDE)

FIGURE 10

HI-SHELL000713

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 0

MW-8 0

MW-7 0.35-0.59

MW-13

MW-6 0

MW-10 0

MW-12 0.05-1.56

MW-11 0

Recommended Location of Recovery Well

Former Location of Shell Terminal

MW-5 0

MW-3 0.75

MW-4 0

HC-2 0

Tallow Storage Area

MW-2 0

MW-1 0

N

11th Avenue S. W.

S. W. Florida St.

0 200 400

SCALE IN FEET

EXPLANATION:

MW-7 / 0.36-0.59 — LOCATION OF BORING/MONITOR WELL; MINIMUM AND MAXIMUM FREE PRODUCT THICKNESS BASED ON 6/4/88 MEASUREMENTS

APPROXIMATE EXTENT OF FREE PRODUCT PLUME

NOTE: FREE PRODUCT THICKNESS AT WELL MW-3 BASED ON 10/28/88 MEASUREMENTS

ARCO Tank Yard

OPLC Terminal

Shell Tank Yard

Shell Tank Yard

MW-A4 0.04

MW-A5 0

MW-A1 0

MW-A2 0

TTLR

Shell Tank Truck Loading Facility

MW-A3 0.10

13th Avenue S. W.

S. W. Lander St.

Texaco Tank Yard

0303-24-4 JHB:KKT 2-1-88

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FREE PRODUCT THICKNESS

FIGURE 11

HI-SHELL000714

East Duwamish Waterway

Concrete Apron

Timber Bulkhead

Sheet Pile Bulkhead

MW-9 X=1.2 TPH=0.07

MW-8

MW-7 FP

MW-13 T=6.5 X=9.8 TPH=62

MW-6 E=1.3 T=0.76 X=1.89

MW-10 B=470 T=29 X=31 TPH=20.3

MW-12 FP

MW-11 B=2500 E=150 T=48 X=423 TPH=31.3

MW-5 T=1.2 X=0.98 TPH=0.40

MW-3 B=350 E=0.9 T=7.1 X=72 TPH=1.9

MW-4 X=54 TPH=0.13

Former Location of Shell Terminal

MONITOR WELLS MW-1 THROUGH MW-6, MW-8 AND MW-9 WERE SAMPLED ON 1/30/88.(TPH SAMPLES FROM THESE WELLS WERE COLLECTED ON 5/14/88). MONITOR WELLS MW-10 AND MW-11 WERE SAMPLED ON 5/14/88. MONITOR WELL MW-13 WAS SAMPLE ON 10/28/88.

HC-2

Tallow Storage Area

MW-2 T=0.91 TPH=0.3

MW-1 T=0.71 TPH=0.27 TL=0.004

N

11th Avenue S. W.

S. W. Florida St.

0 200 400

SCALE IN FEET

ARCO Tank Yard

OPLC Terminal

Shell Tank Yard

Shell Tank Yard

MW-A4

MW-A5

Shell Tank Truck Loading Facility

MW-A1

TTLR

MW-A2

MW-A3

13th Avenue S. W.

Texaco Tank Yard

S. W. Lander St.

EXPLANATION:

MW-1 ● LOCATION OF BORING/MONITOR WELL

COMPOUNDS DETECTED IN GROUND WATER FROM MONITOR WELL

B=BENZENE (PPB)

E=ETHYLBENZENE (PPB)

T=TOLUENE (PPB)

X=SUM OF M, O & P XYLENES (PPB)

TPH=PETROLEUM HYDORCARBONS (PPM)

TL=DISSOLVED TOTAL LEAD (PPM)

FP=FREE PRODUCT PRESENT AT TIME OF SAMPLE COLLECTION

NOTE: COMPOUNDS NOT LISTED WERE NOT

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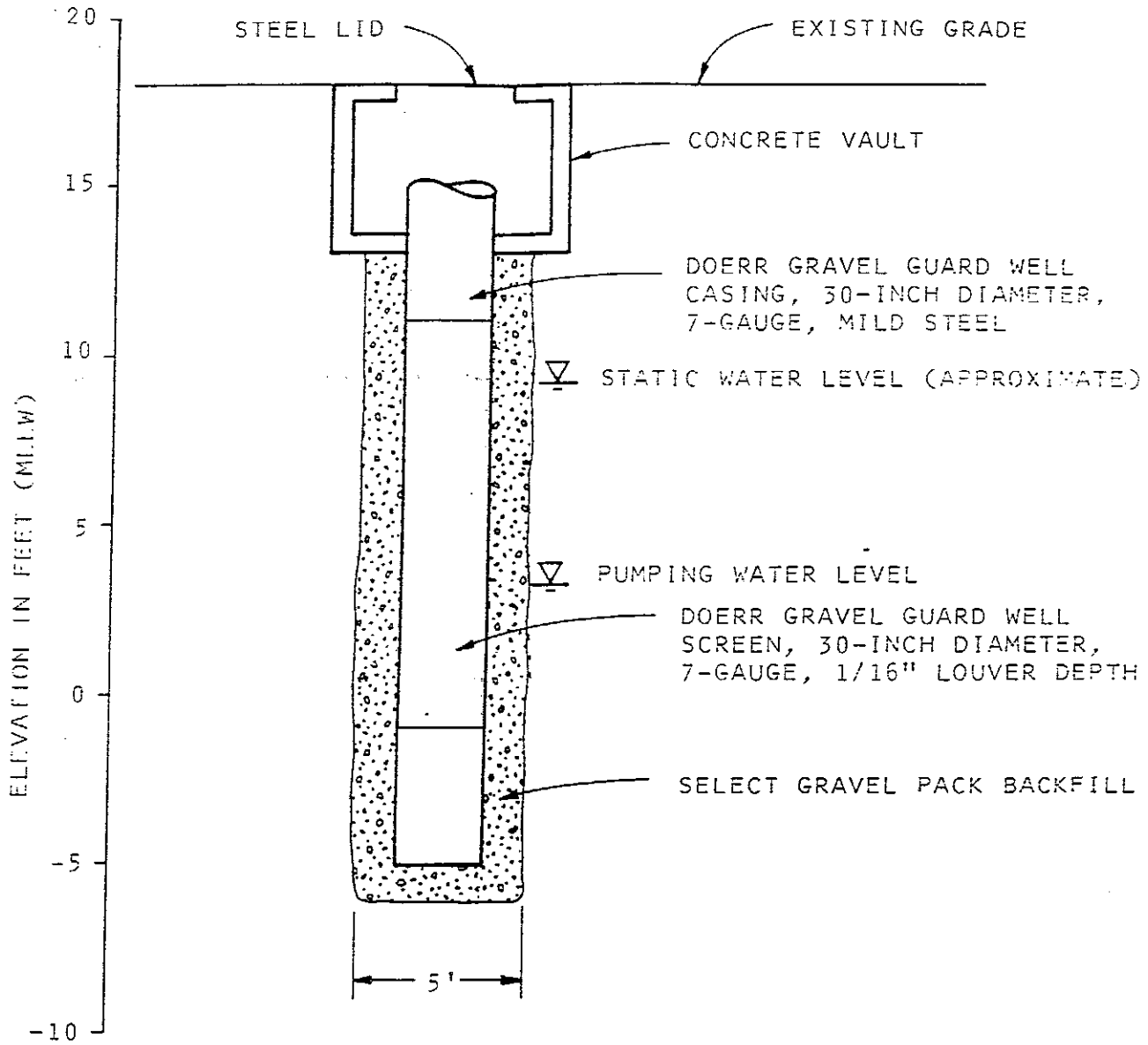
ANALYTICAL DATA

HI-SHELL000715



SCALE: 1"=5'

NOTE: RECOVERY SYSTEM WILL CONSIST OF "ORS WATER TABLE DEPRESSION PUMP AND SCAVENGER PRODUCT RECOVERY PUMP" WITH RELATED FLUID LEVEL PROBES.

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RECOVERY WELL SCHEMATIC

FIGURE 13

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APPENDIX A

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APPENDIX A

FIELD EXPLORATIONS

DRILLING AND SOIL SAMPLING PROGRAM

Subsurface conditions at the former Shell terminal were explored by drilling thirteen borings (Borings MW-1 through MW-13) at the locations indicated in Figures 2 and 4. Borings MW-1 through MW-5, MW-7 and MW-8 were drilled on December 16, 1987. Borings MW-6 and MW-9 were drilled on January 8, 1988. Borings MW-10 through MW-12 were drilled on April 30, 1988. Boring MW-13 was drilled on October 13, 1988. The borings were drilled to depths of about 15 to 20 feet using truck-mounted, hollow-stem auger drilling equipment. The drilling and soil sampling equipment was cleaned with a hot-water pressure washer between each boring. The soil sampling equipment was washed in a trisodium phosphate solution, rinsed with a hot-water pressure washer, and rinsed again with distilled water rinse prior to each sample attempt.

A geologist from our staff determined the boring locations, examined and classified the soils encountered, and prepared a detailed log of each boring. Soils encountered were classified visually in general accordance with ASTM D-2488-83, which is described in Figure A-1. An explanation of the boring log symbols is presented in Figure A-2. The boring logs are given in Figures A-3 through A-15.

Relatively undisturbed soil samples were obtained from each boring at about 5 foot intervals using a 2.4 inch I.D. split-spoon sampler. The sampler was driven 18 inches by a 300-pound weight falling a vertical distance of approximately 30 inches. The number of blows needed to advance the sampler the final 12 inches is indicated to the left of the corresponding sample notations on the boring logs.

Sieve analyses were performed on several soil samples to determine soil grain-size distributions. The results of the sieve analyses are given in Figures A-16 to A-20.

GENERAL GROUND WATER QUALITY

The temperature, pH and electrical conductivity of ground water which was bailed from the monitor wells during sample collection were measured with Whatman pH, temperature and conductivity sensors. The calibration of the pH and conductivity sensors was checked against standard solutions prior to measurements at each well. The calibration of the temperature sensor was compared to a laboratory thermometer prior to use in the field. The results of these measurements are summarized in the main body of this report.

GROUND WATER ELEVATION AND FREE PRODUCT THICKNESS

The depth to the ground water table relative to the monitor well casing rims was measured several times during two tide cycles on February 6 and June 4, 1988. A single round of well measurements was also conducted on October 28, 1988. The measurements were made in Monitor Wells MW-7, MW-12 and MW-A1 through MW-A5 using a weighted fiberglass tape and water-finding paste. The measurements were made in Monitor Wells MW-1 through MW-6, MW-8 through MW-11 and HC-2 with an electric sounder. Equipment which came in contact with the well casings was washed in a trisodium phosphate wash followed by a distilled water rinse prior to insertion in each well. Ground water elevation was calculated by subtracting the water table depth from the casing rim elevation. Free product thickness was calculated by subtracting the depth to water from the depth to product. Water table and free product positions measured on February 6, June 4, or October 28, 1988 are shown on the monitor well logs.

Plots of the elevation of the ground water table in each monitor well and the elevation of the East Duwamish Waterway during approximately 12-hour periods on February 6 and June 4, 1988 are shown in Figures A-21 through A-52.

HYDROCARBON VAPOR CONCENTRATIONS

Hydrocarbon vapor concentrations were measured in the monitor wells on February 6 and June 4, 1988. Vapor concentrations in parts per

million (ppm) were measured with our Bacharach TLV Sniffer, which is calibrated to hexane. The field data are presented in Table 1 of this report.

ANALYTICAL PROGRAM

The water and product samples were analyzed by Analytical Technologies, Inc. The water samples were analyzed for purgeable aromatics by EPA Method 602, total recoverable petroleum hydrocarbons by EPA Method 418.1, and organic and total lead by EPA Method 7421. The petroleum product samples were analyzed for product type, flash point, and API gravity by EPA Methods 8010 (modified), 1010 (modified) and ASTM D287, respectively. Analytical, QA and Chain of Custody reports are given in Appendix B.

Contaminants were not detected in the rinseate or trip blank samples. The results for the blind and duplicate analyses are generally within acceptable limits and are given in Appendix B.

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-83.
2. Soil classification using laboratory tests is based on ASTM D2487-83.
3. Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water

Wet - Visible free water or saturated, usually soil is obtained from below water table

GEI 85-85

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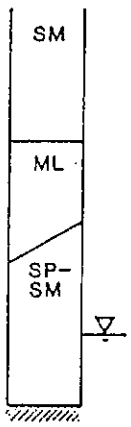
SOIL CLASSIFICATION SYSTEM

FIGURE A - 1

LABORATORY TESTS:

AL	Atterberg limits
CP	Compaction
CS	Consolidation
DS	Direct shear
GS	Grain-size analysis
HA	Hydrometer analysis
K	Permeability
M	Moisture content
MD	Moisture and density
SP	Swelling pressure
TX	Triaxial compression
UC	Unconfined compression
CA	Chemical Analysis

SOIL GRAPH:



Soil Group Symbol (See Note 1)

Distinct contact between Soil Strata

Gradual Change between Soil Strata

Water Level

Bottom of Boring

BLOW-COUNT/SAMPLE DATA:

Blows required to drive Dames & Moore sampler 12 inches or other indicated distances using pound hammer falling inches.

"P" indicates sampler pushed with weight of hammer or hydraulics of drill rig.

22 ■ Location of relatively undisturbed sample

12 ⊠ Location of disturbed sample

P □ Location of sampling attempt with no recovery

10 ◪ Location of sample attempt using Standard Penetration Test procedures

40 ⬓ Location of relatively undisturbed sample using 140 pound hammer falling 30 inches.

NOTES:

1. Soil classification system is summarized in Figure A-1.
2. The reader must refer to the discussion in the report text as well as the exploration logs for a proper understanding of subsurface conditions.

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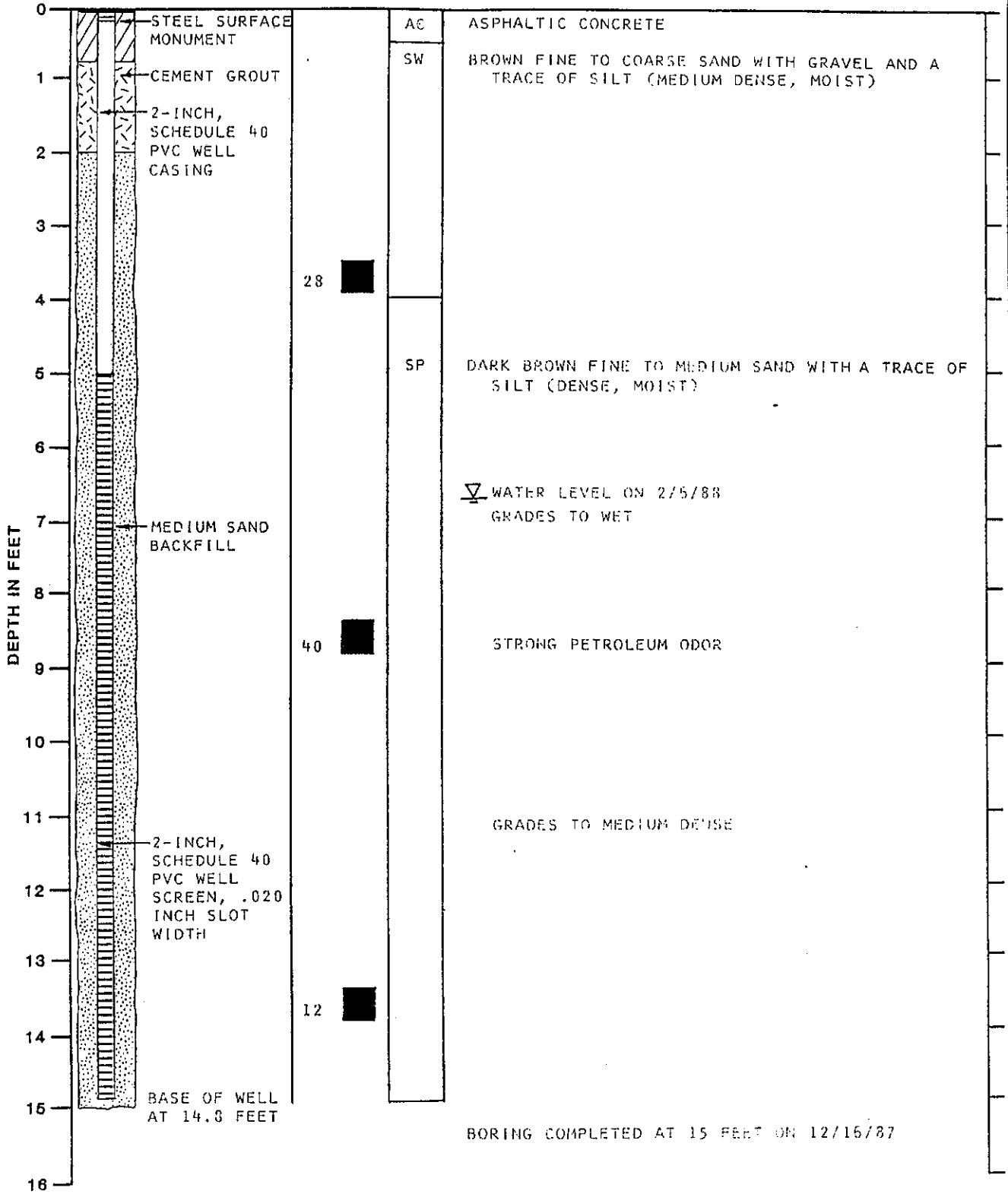
KEY TO BORING LOG SYMBOLS

FIGURE A-2

MONITOR WELL NO. MW-1



Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

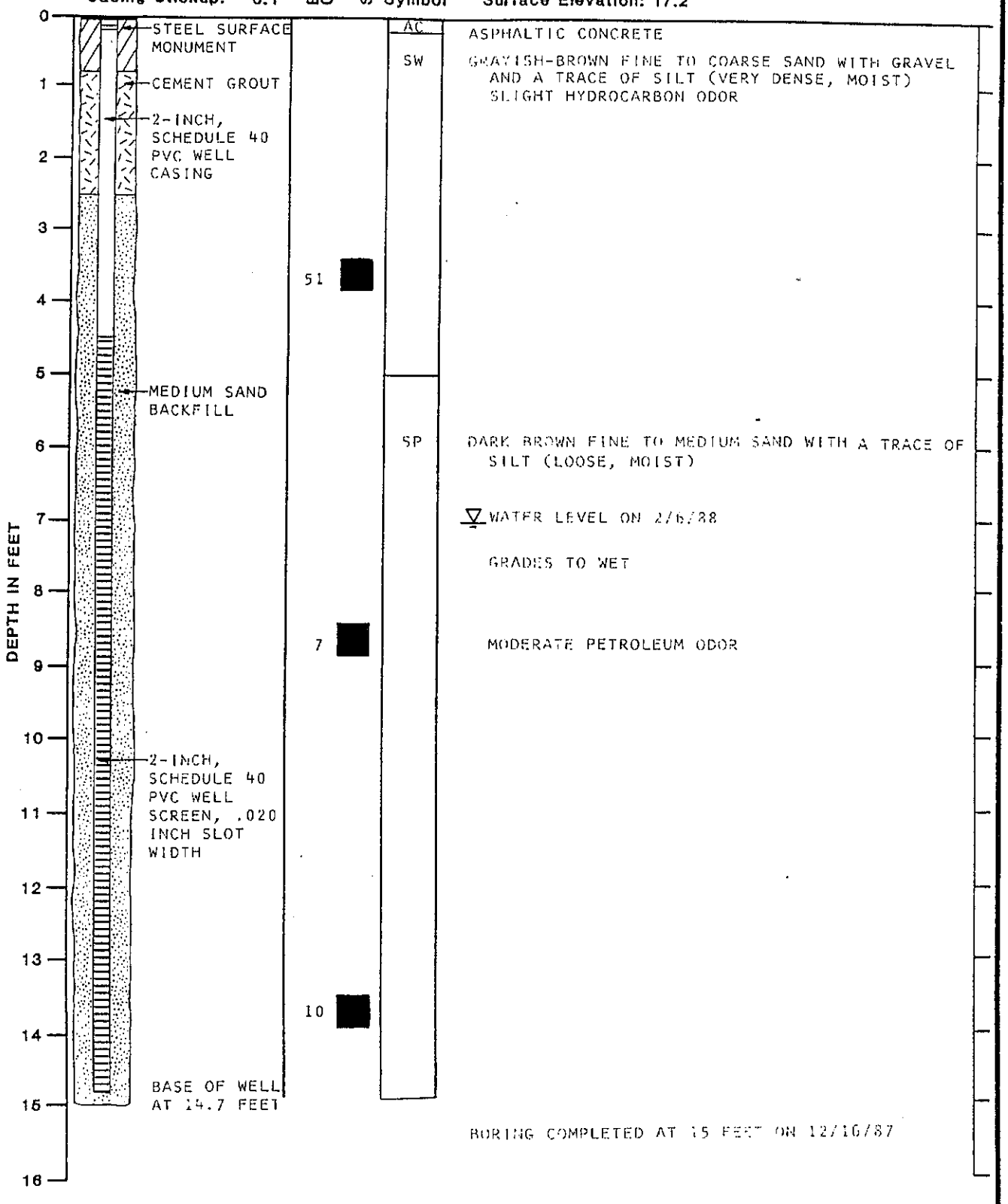
FIGURE A-3

12/18/87

TTF:TN:KKT

0303-24-4

MONITOR WELL NO. MW-2



Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

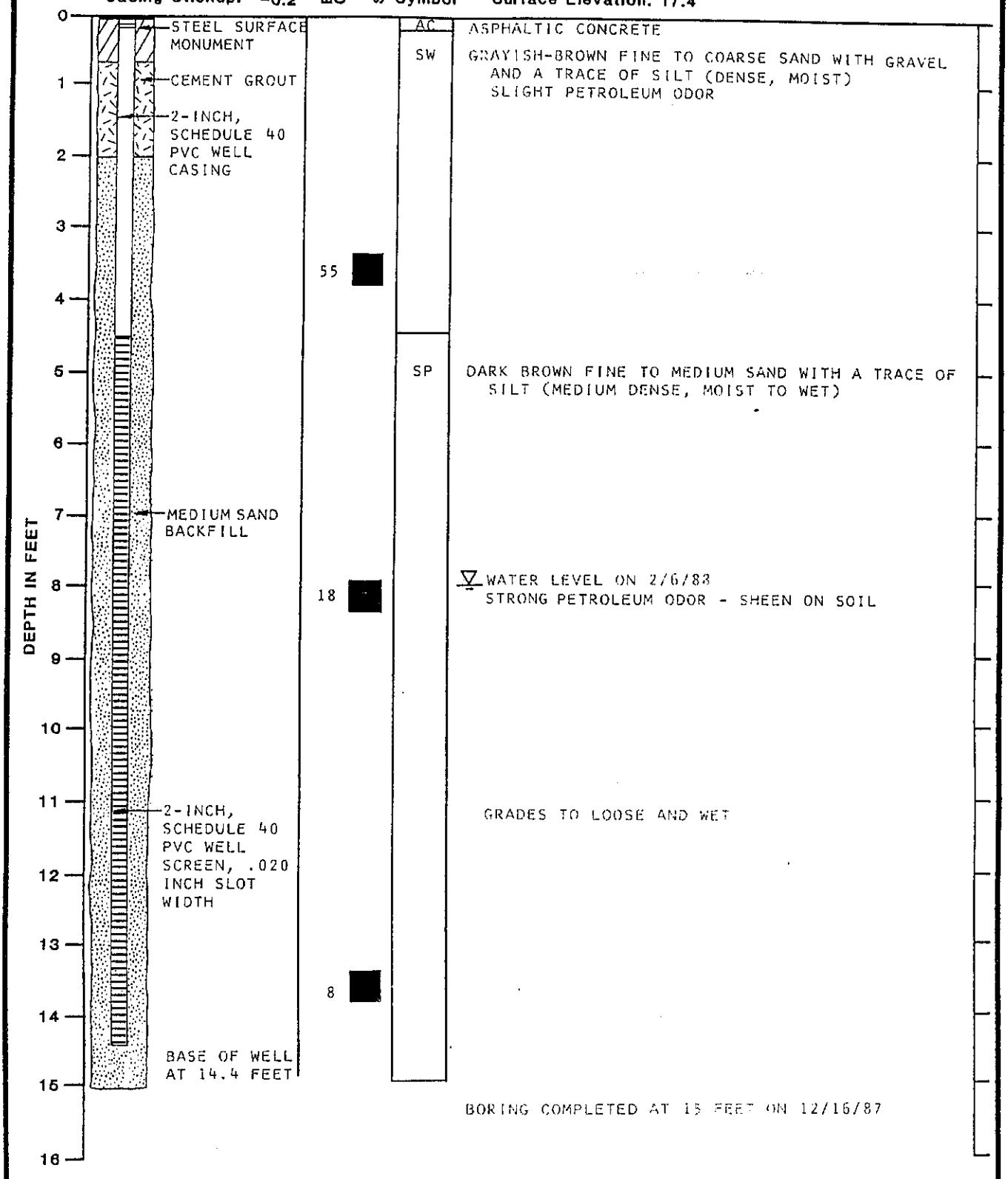
FIGURE A-4

12/18/87

TTF:TN:KKT

0303-24-4

MONITOR WELL NO. MW-3



Note: See Figure A-2 for Explanation of Symbols

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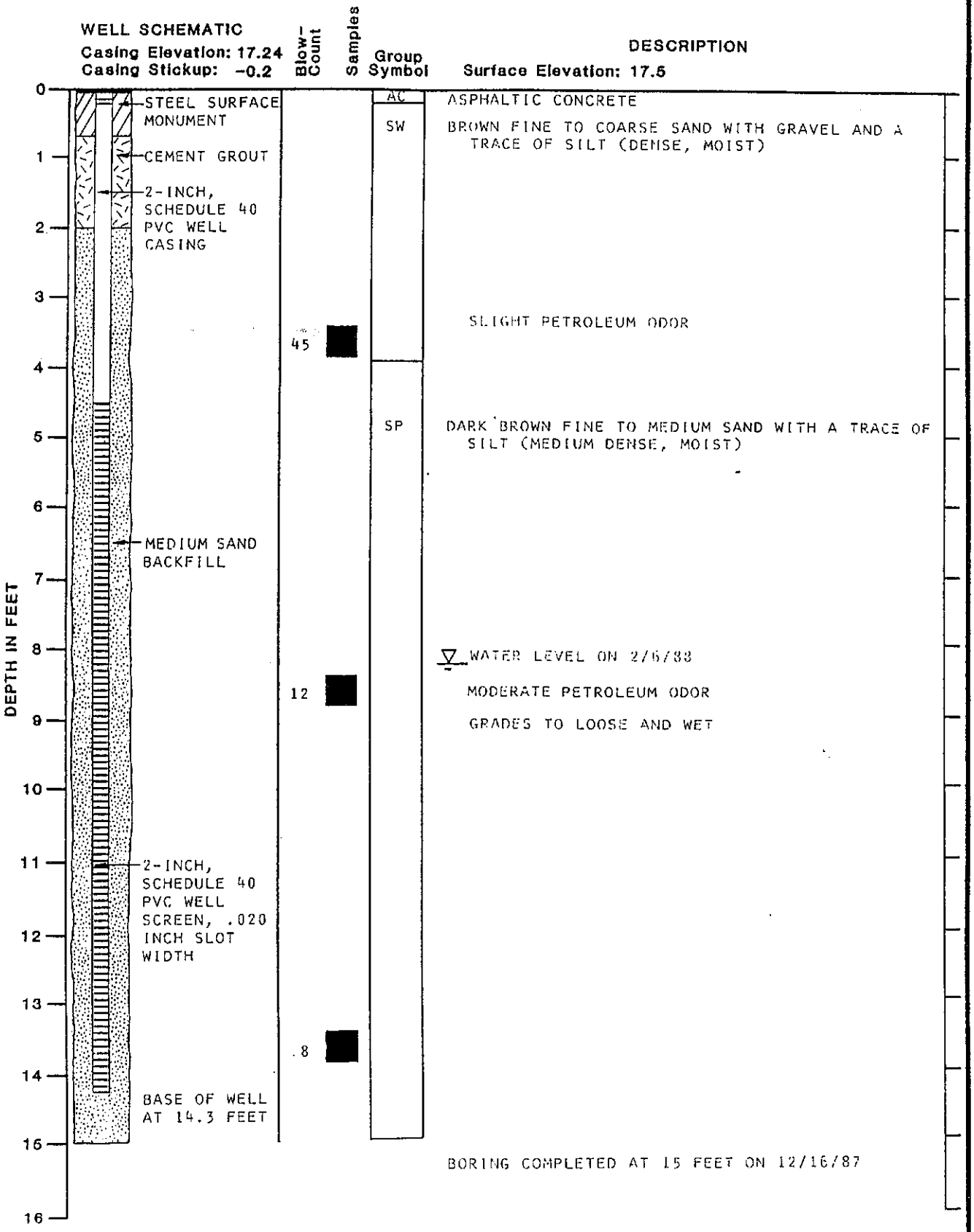
LOG OF MONITOR WELL

FIGURE A-5

0303-24-4 TTF:TN:KKT 12/18/87

MONITOR WELL NO. MW-4



Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

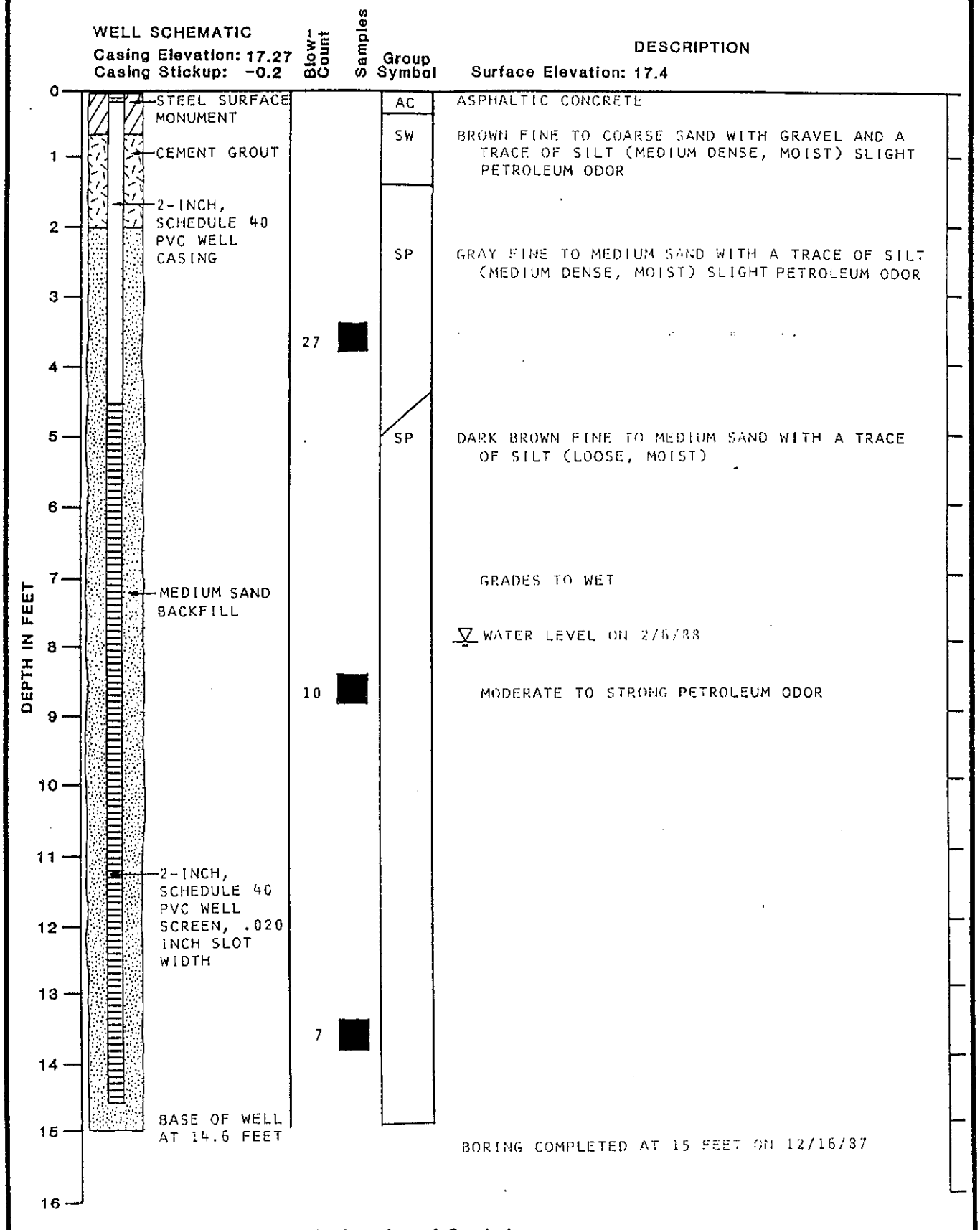
FIGURE A-6

12/18/87

TTF:TN:KKT

0303-24-4

MONITOR WELL NO. MW-5



Note: See Figure A-2 for Explanation of Symbols

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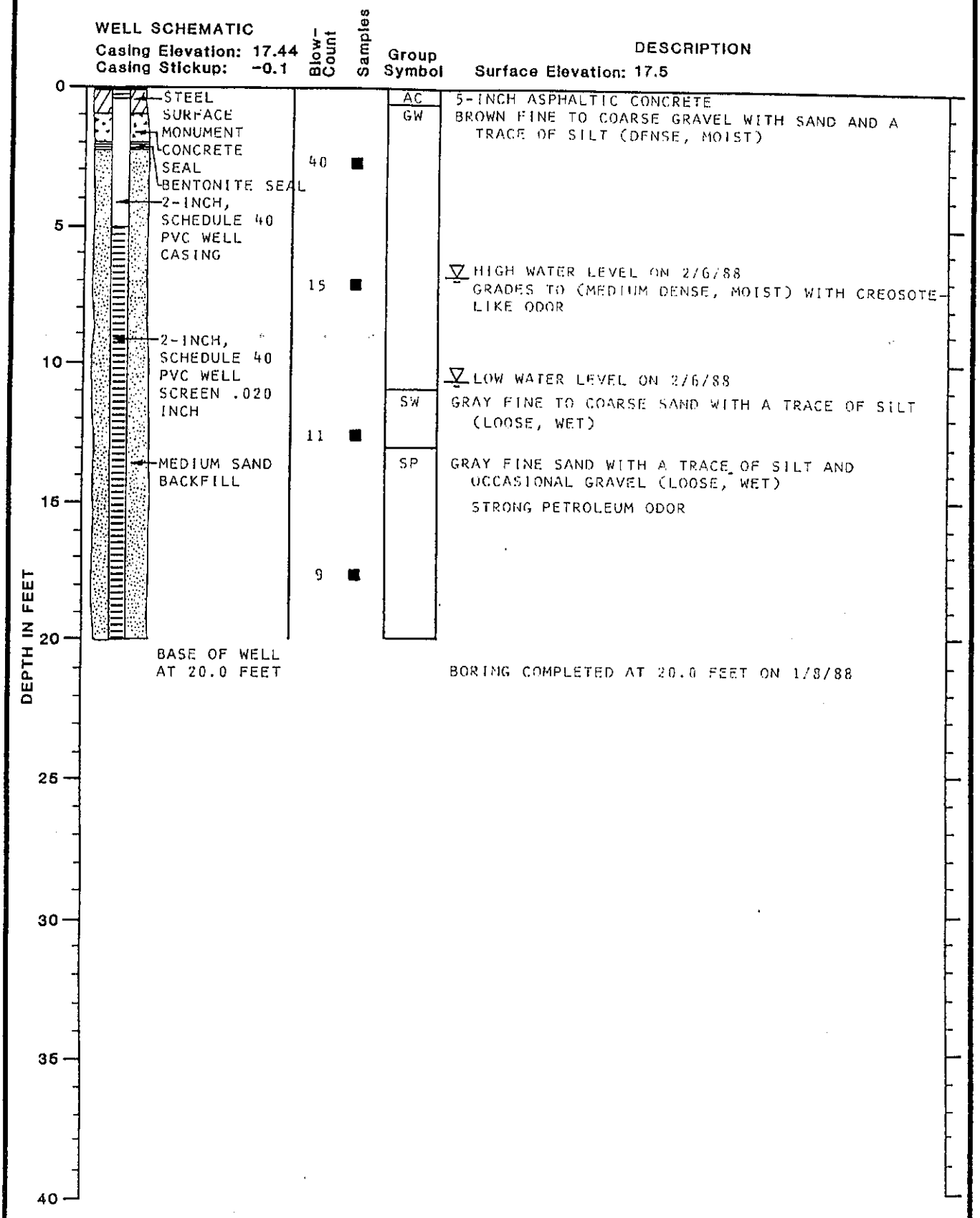
LOG OF MONITOR WELL

FIGURE A-7

0303-24-4 TTF:TN:KKT 12/18/87

MONITOR WELL NO. MW-6



Note: See Figure A-2 for Explanation of Symbols

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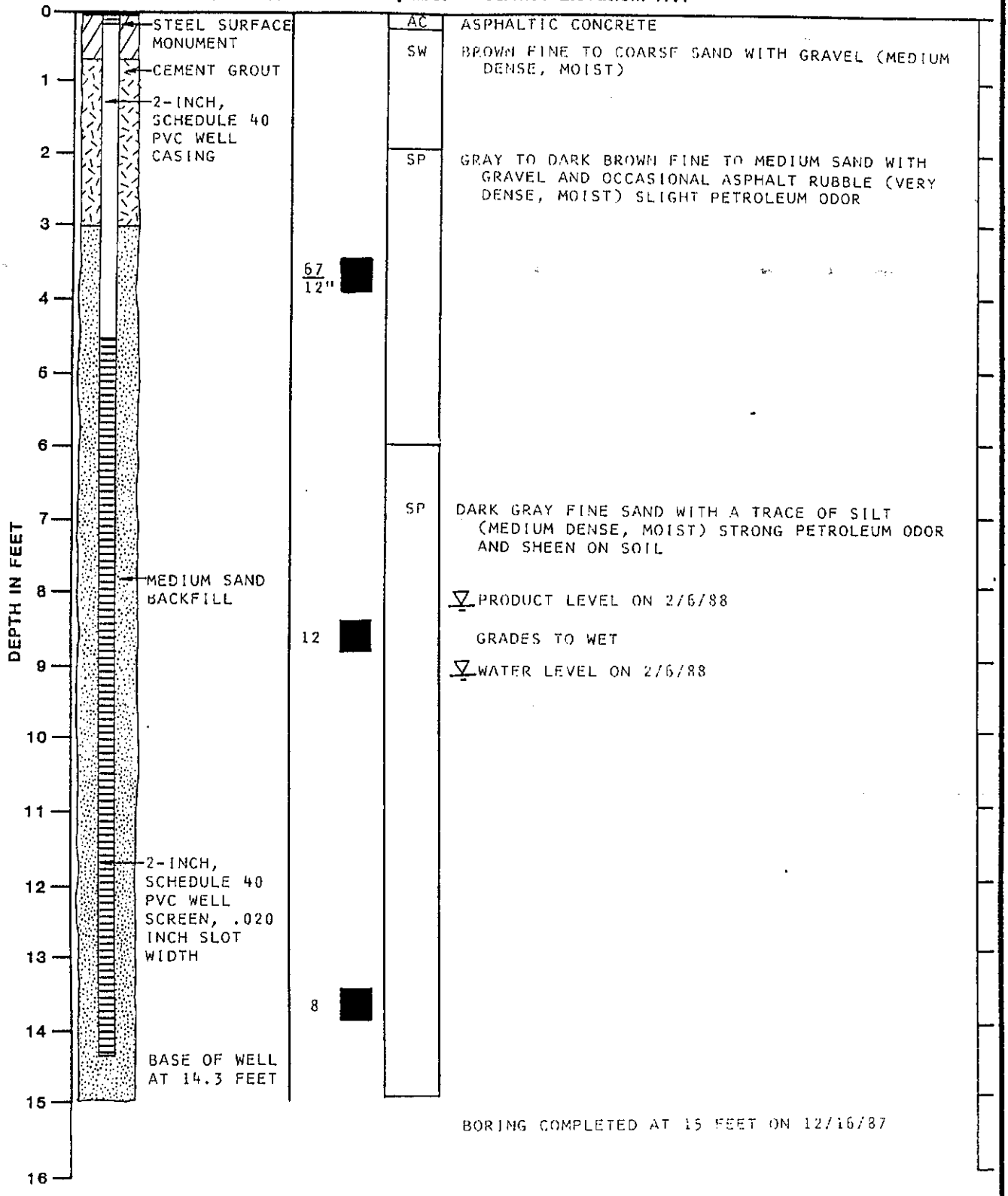
LOG OF MONITOR WELL

FIGURE A-8

0303-24-4 CLH:JHB:ELT:KKT 1-21-88

MONITOR WELL NO. MW-7



Note: See Figure A-2 for Explanation of Symbols

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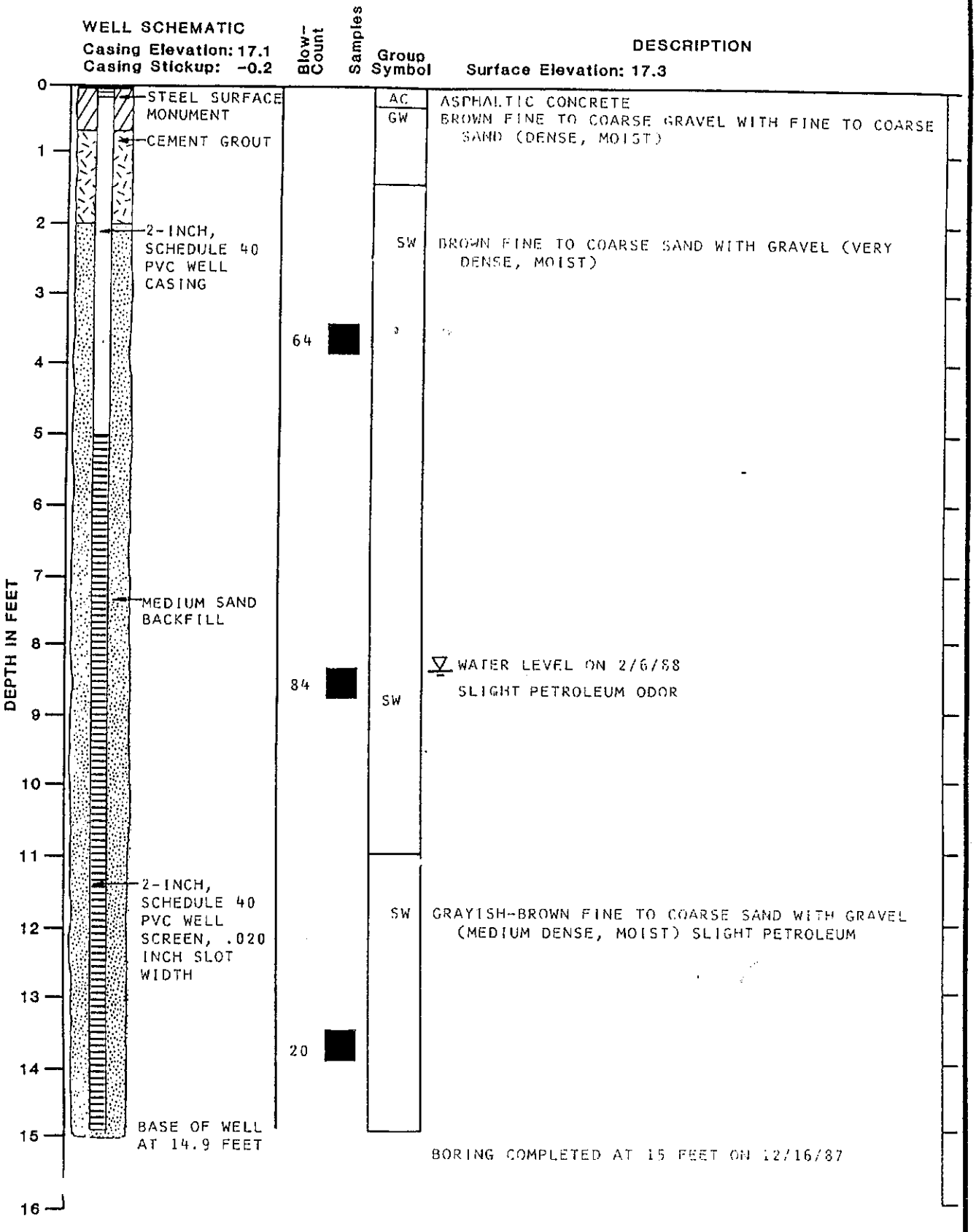
LOG OF MONITOR WELL

FIGURE A-9

0303-24-4 TTF:TN:KKT 12/18/87

MONITOR WELL NO. MW-8



Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

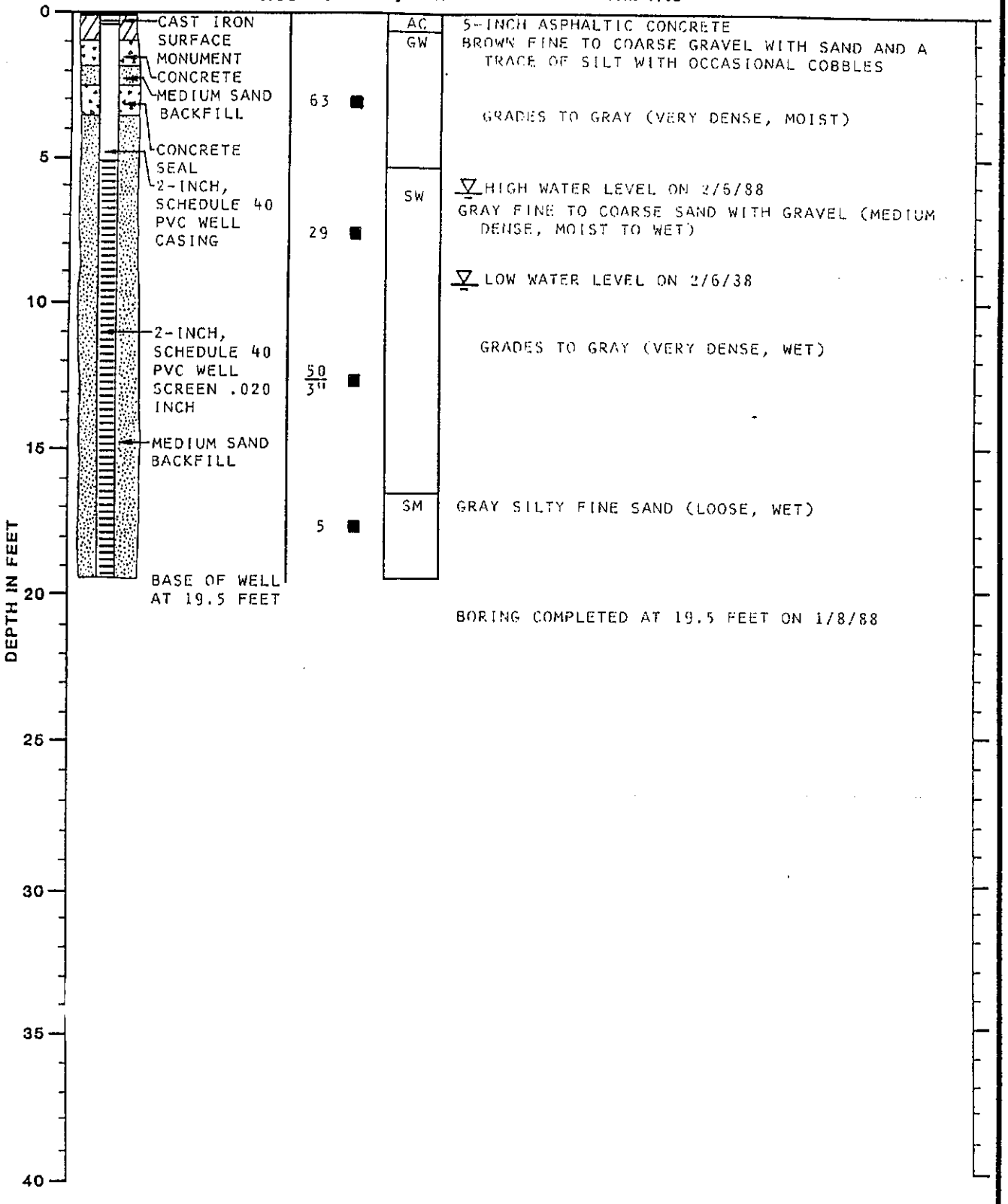
FIGURE A-10

12/18/87

TTF:TN:KKT

0303-24-4

MONITOR WELL NO. MW-9



Note: See Figure A-2 for Explanation of Symbols

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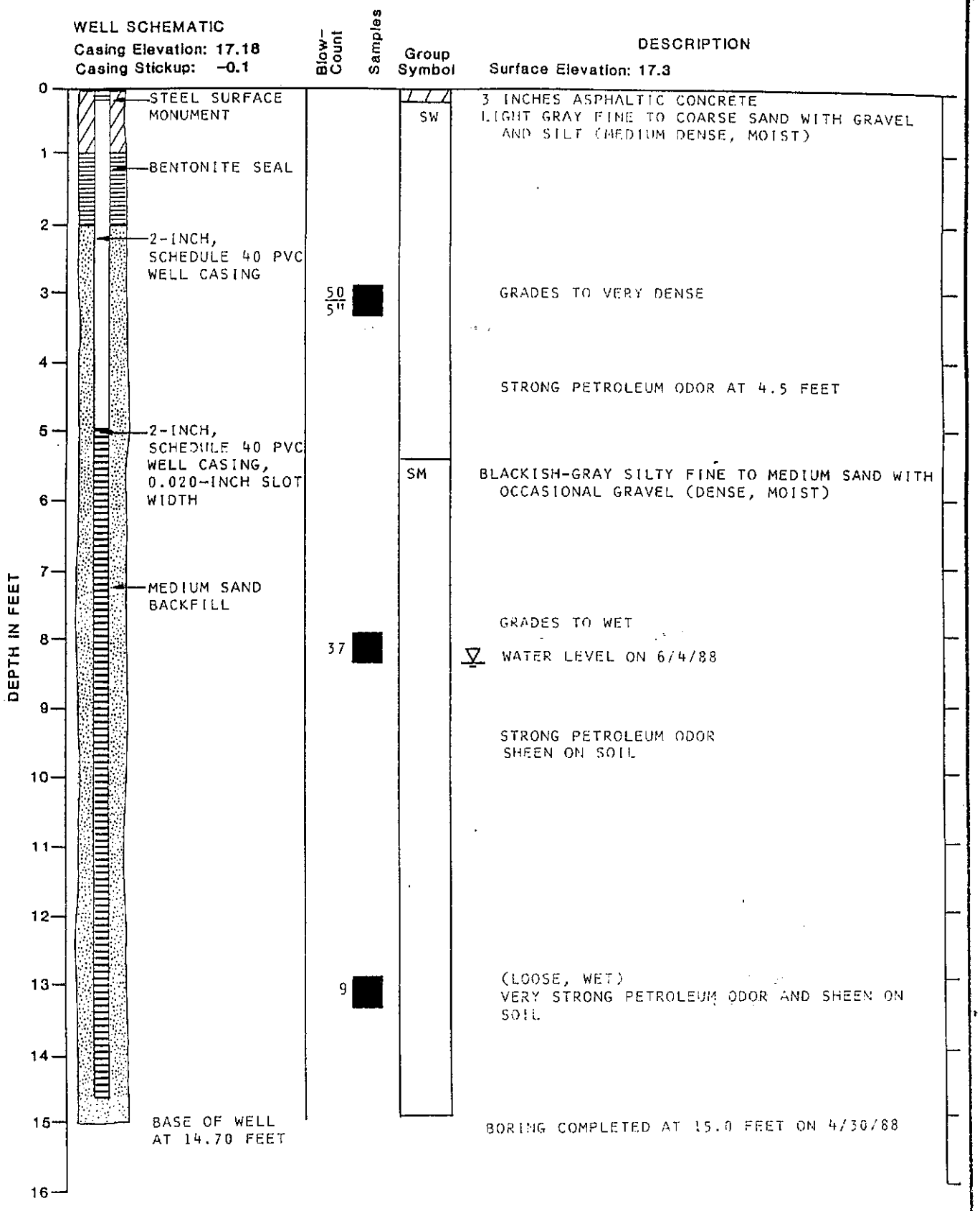
LOG OF MONITOR WELL

FIGURE A-11

0303-24-4 CLH:JHB:ELT:KKT 1-21-88

MONITOR WELL NO. MW-10



Note: See Figure A-2 for Explanation of Symbols

0303-24-4 CLH:JHB:EL 05/03/88

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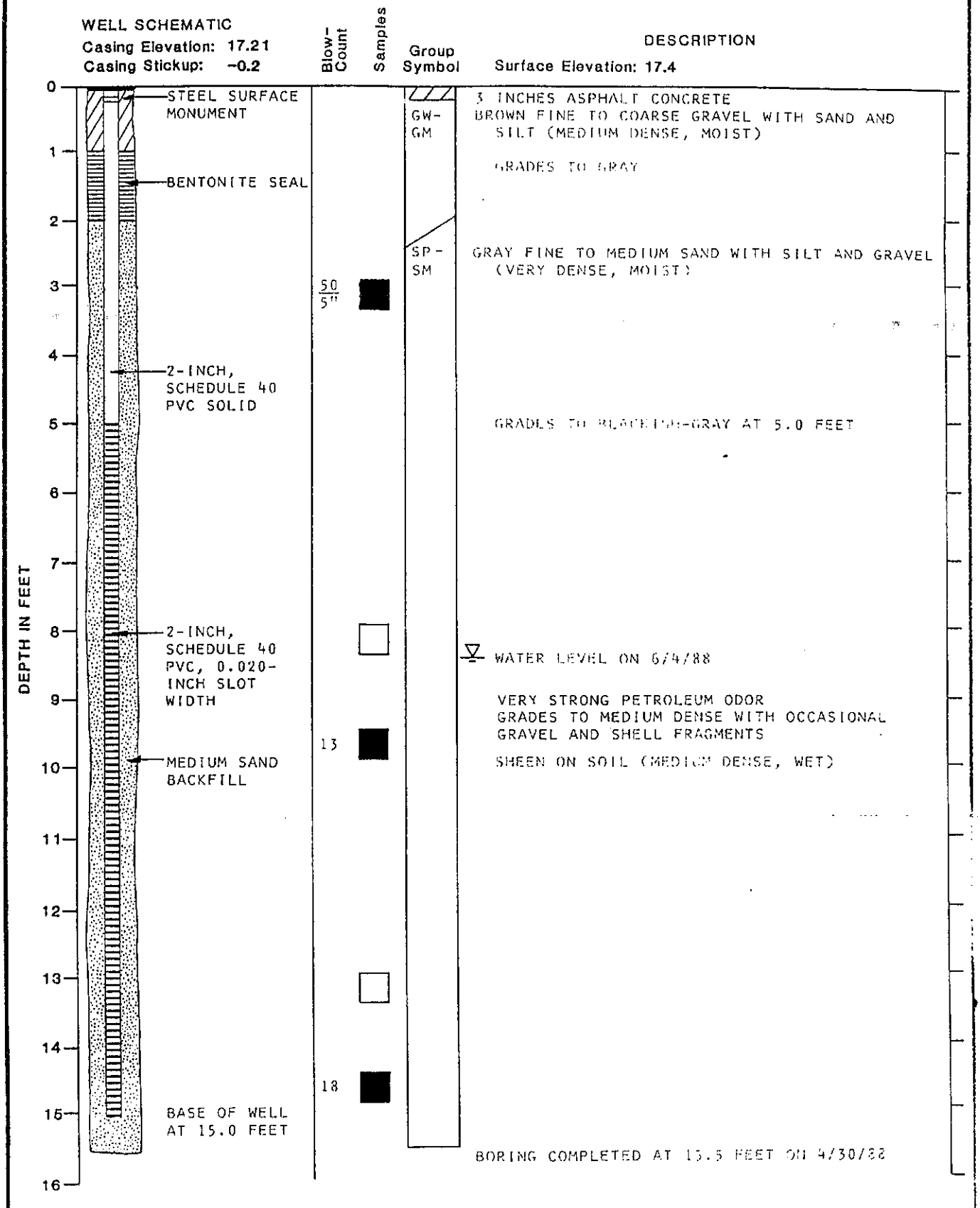
LOG OF MONITOR WELL

FIGURE A-12

MONITOR WELL NO. MW-11



Note: See Figure A-2 for Explanation of Symbols

0303-24-4 CLH:JHB:EL 05/03/88

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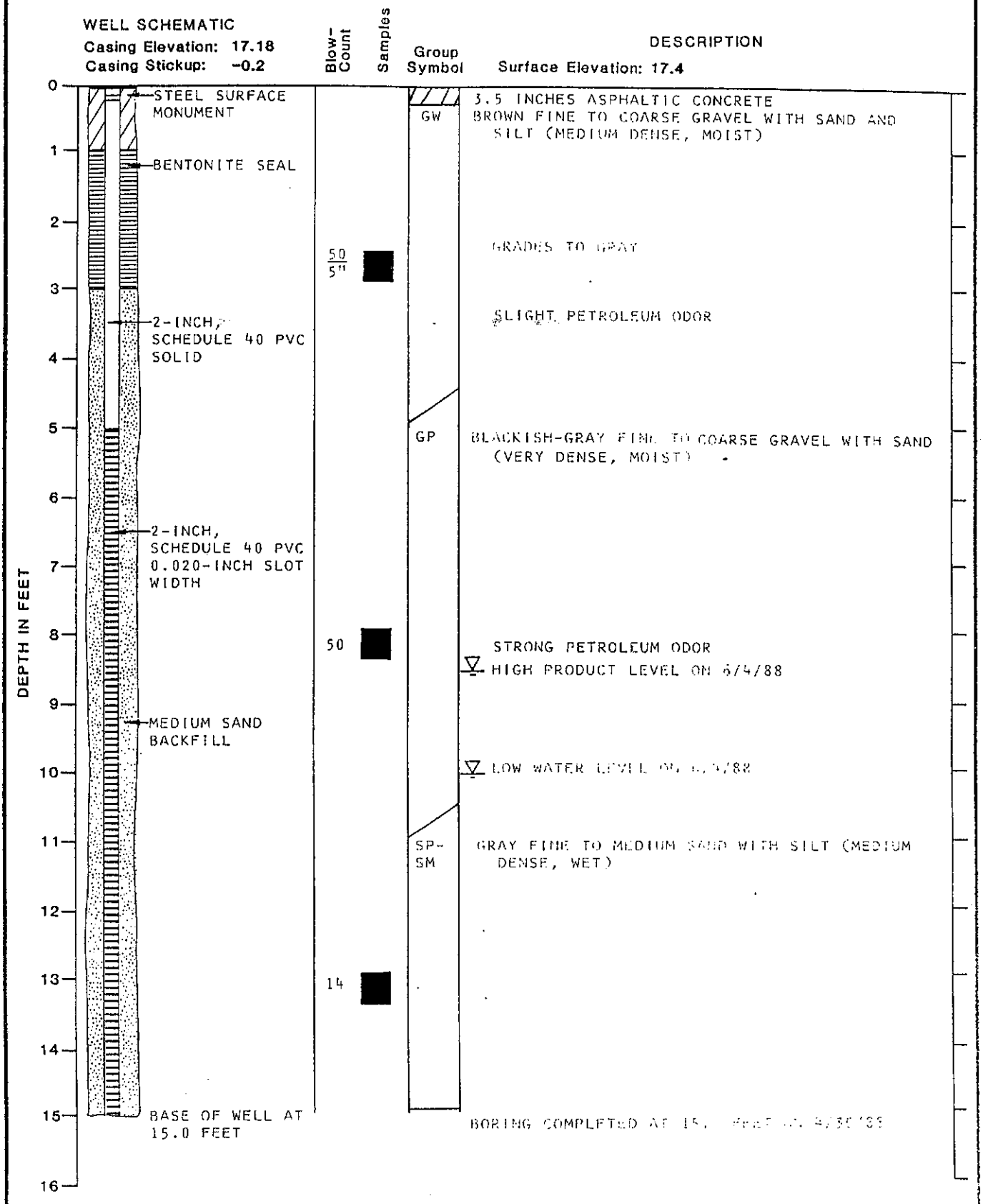
LOG OF MONITOR WELL

FIGURE A-13

MONITOR WELL NO. MW-12



Note: See Figure A-2 for Explanation of Symbols

0303-24-4 CH:JHB:EL 05/03/88

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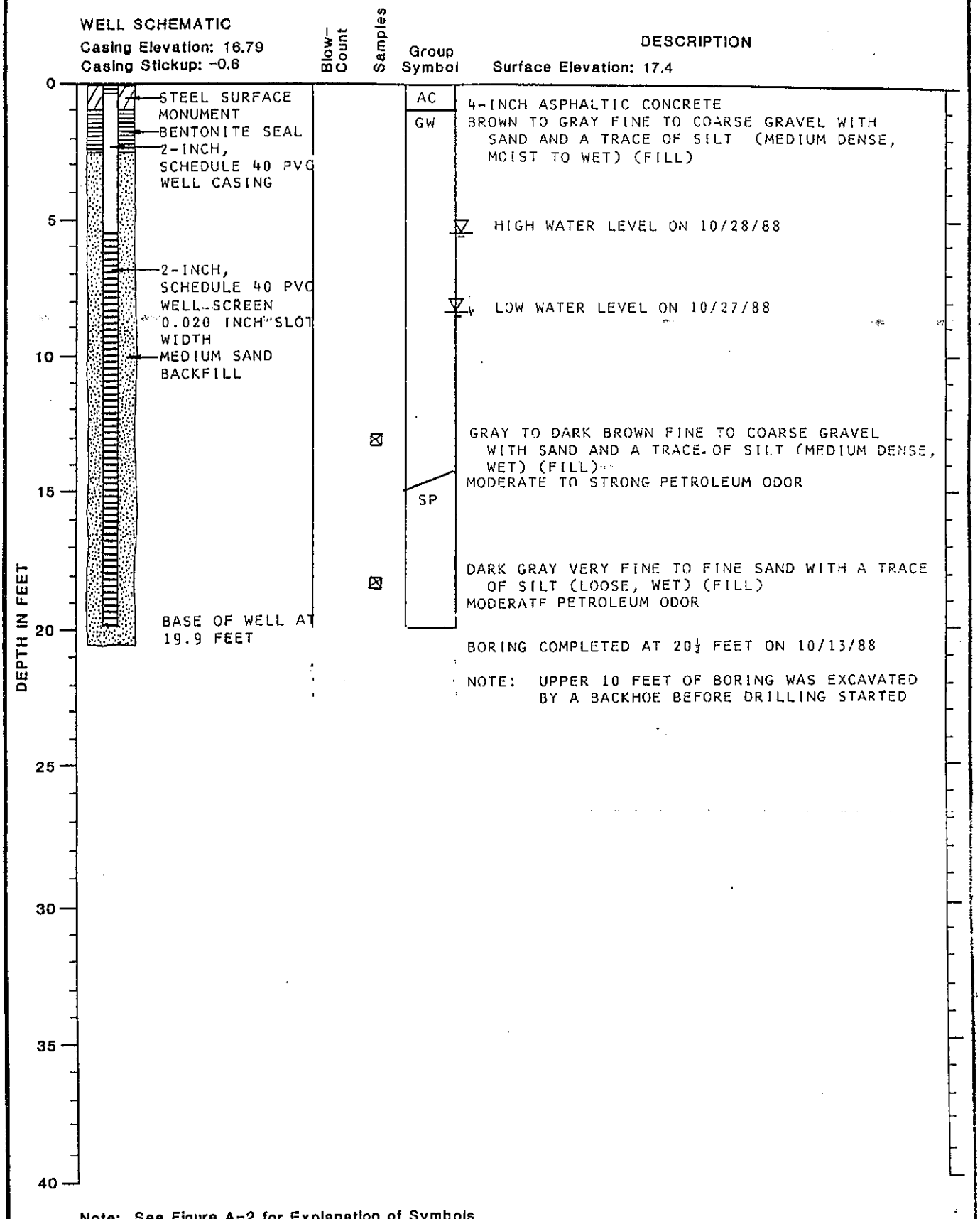
LOG OF MONITOR WELL

FIGURE A-14

MONITOR WELL NO. MW-13



Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

FIGURE A-15

0303-24-4

0303-24-4 JHB:KKT 3/23/88

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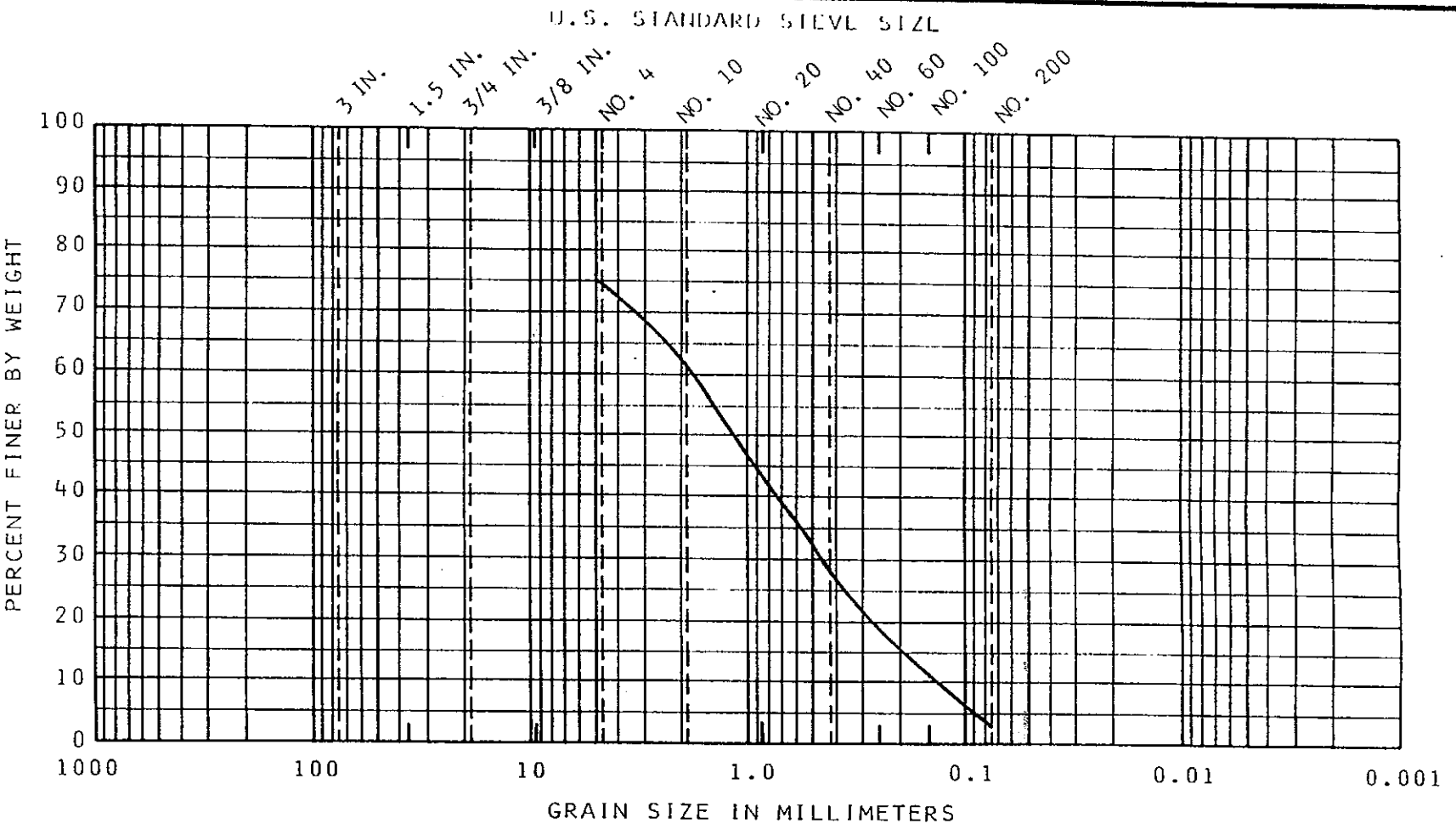

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———	MW-6	17½'	FINE TO CORASE SAND WITH GRAVEL (SW)

GRADATION CURVES

FIGURE A-16

0303-24-4 JHB:KKT 3-23-88

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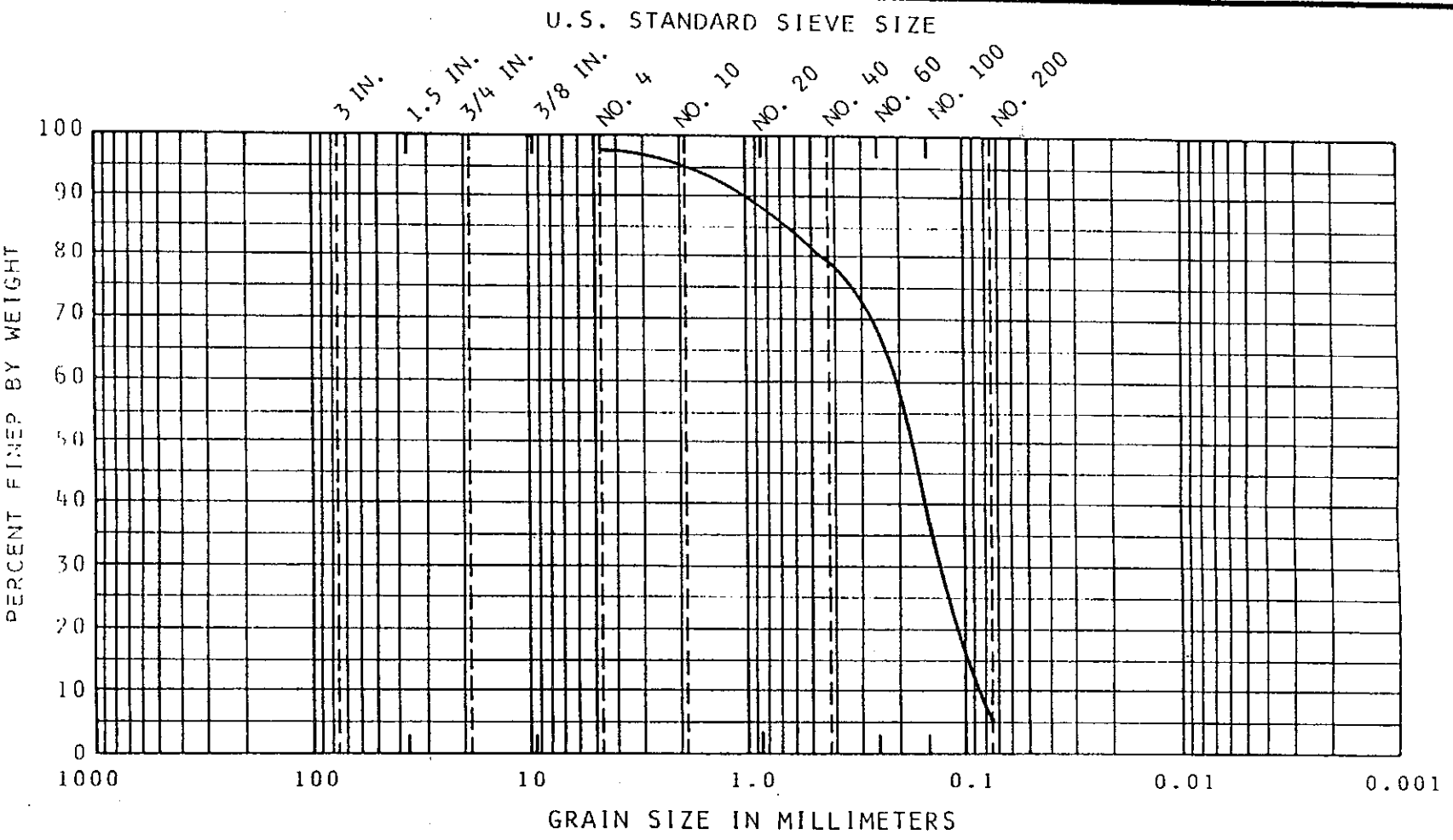

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———	MW-7	13½'	FINE SAND WITH A TRACE OF SILT (SP)

GRADATION CURVES

FIGURE A-17

0303-24-4 JHB:KKT 3-23-88

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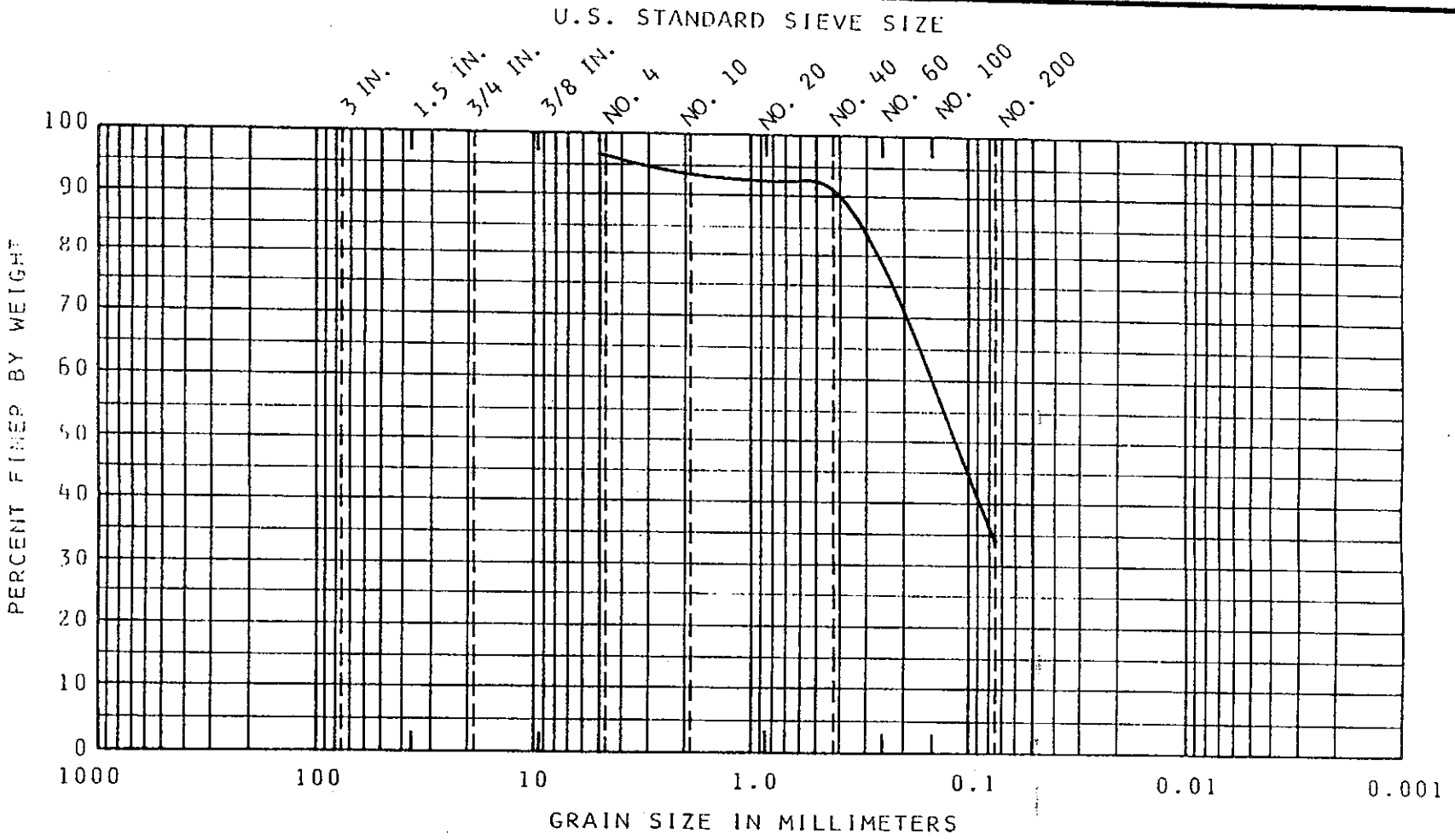
GRADATION CURVES

FIGURE A-18



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———	MW-9	17½'	SILTY FINE SAND (SM)

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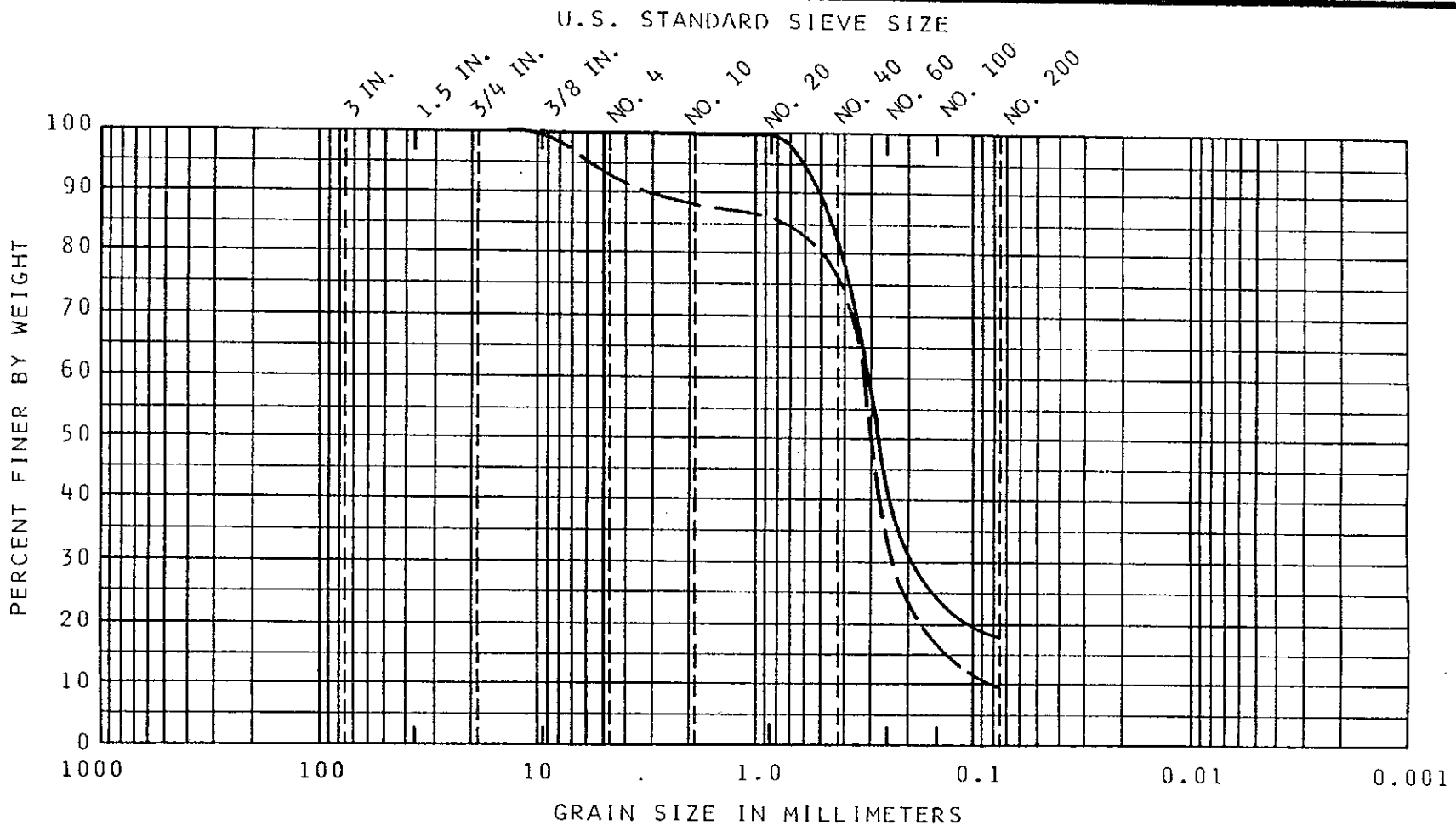

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———	MW-10	8'	GRAY SILTY FINE TO MEDIUM SAND (SM)
— — —	MW-11	10'	GRAY FINE TO MEDIUM SAND WITH SILT (SP-SM)

GRADATION CURVES

FIGURE A-19

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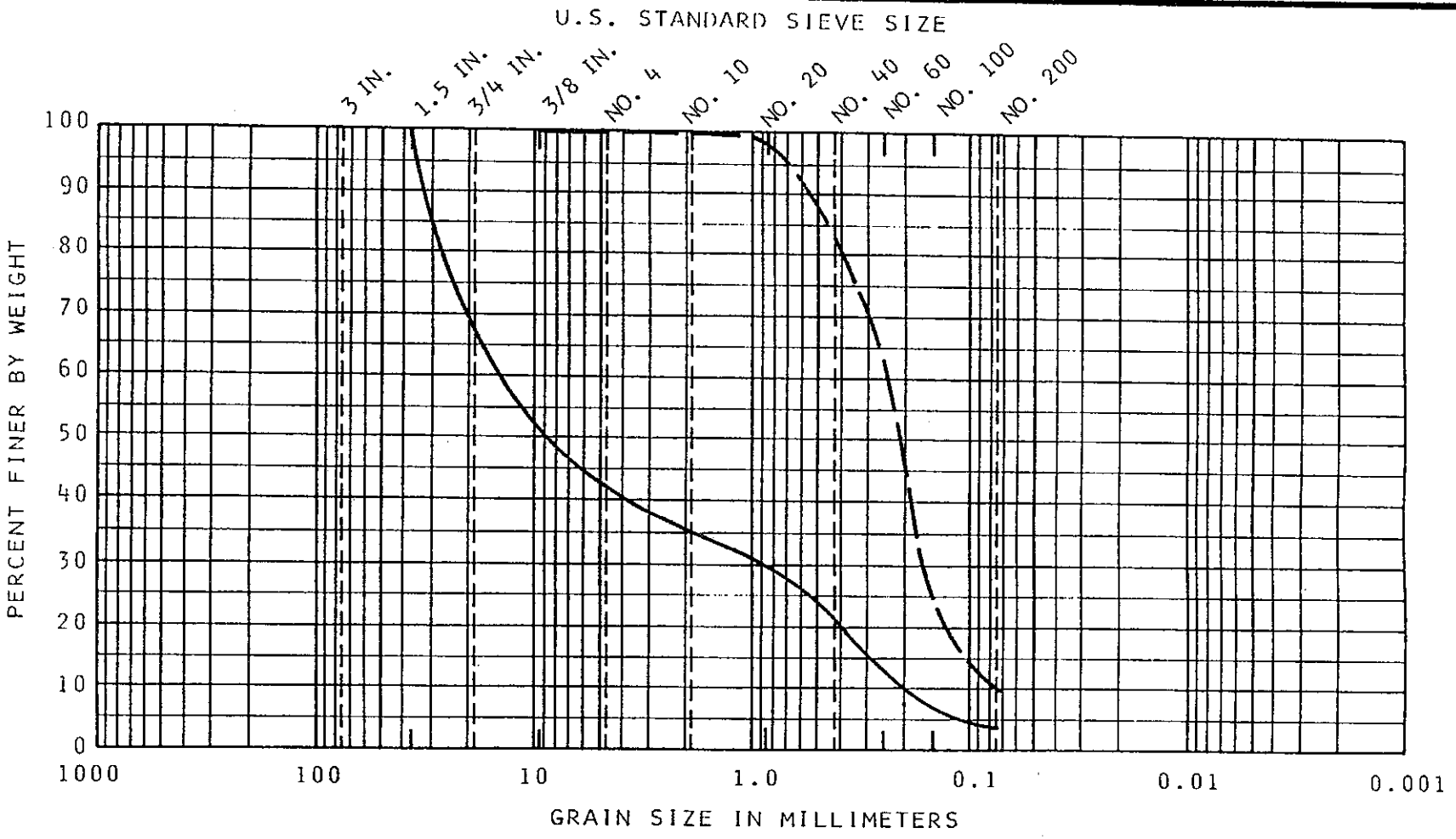
GRADATION CURVES

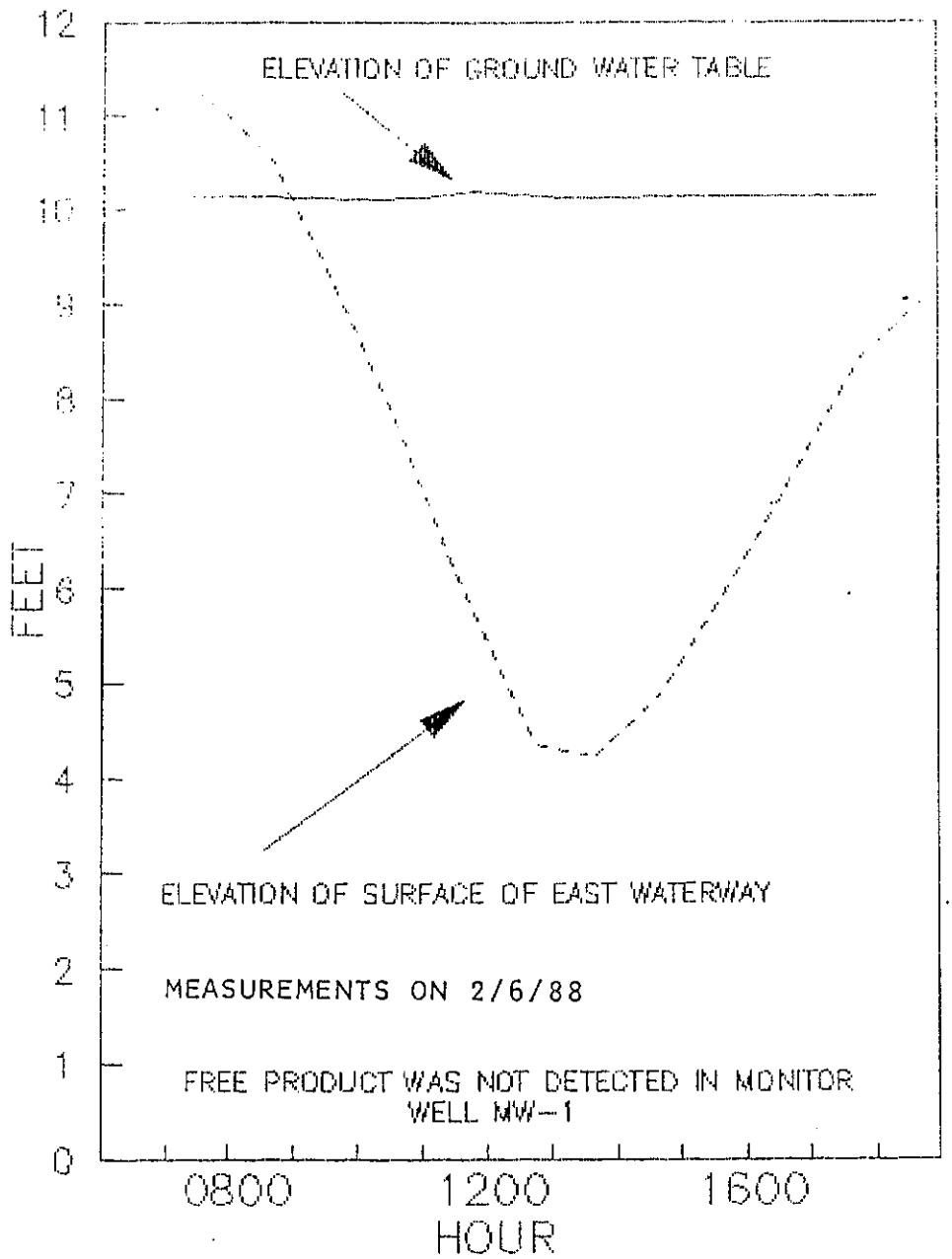
FIGURE A-20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	SOIL DESCRIPTION
———	MW-12	8'	GRAY FINE TO COARSE GRAVEL WITH SAND (GP)
— — —	MW-12	13'	GRAY FINE TO MEDIUM SAND WITH SILT (SP-SM)

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW-1



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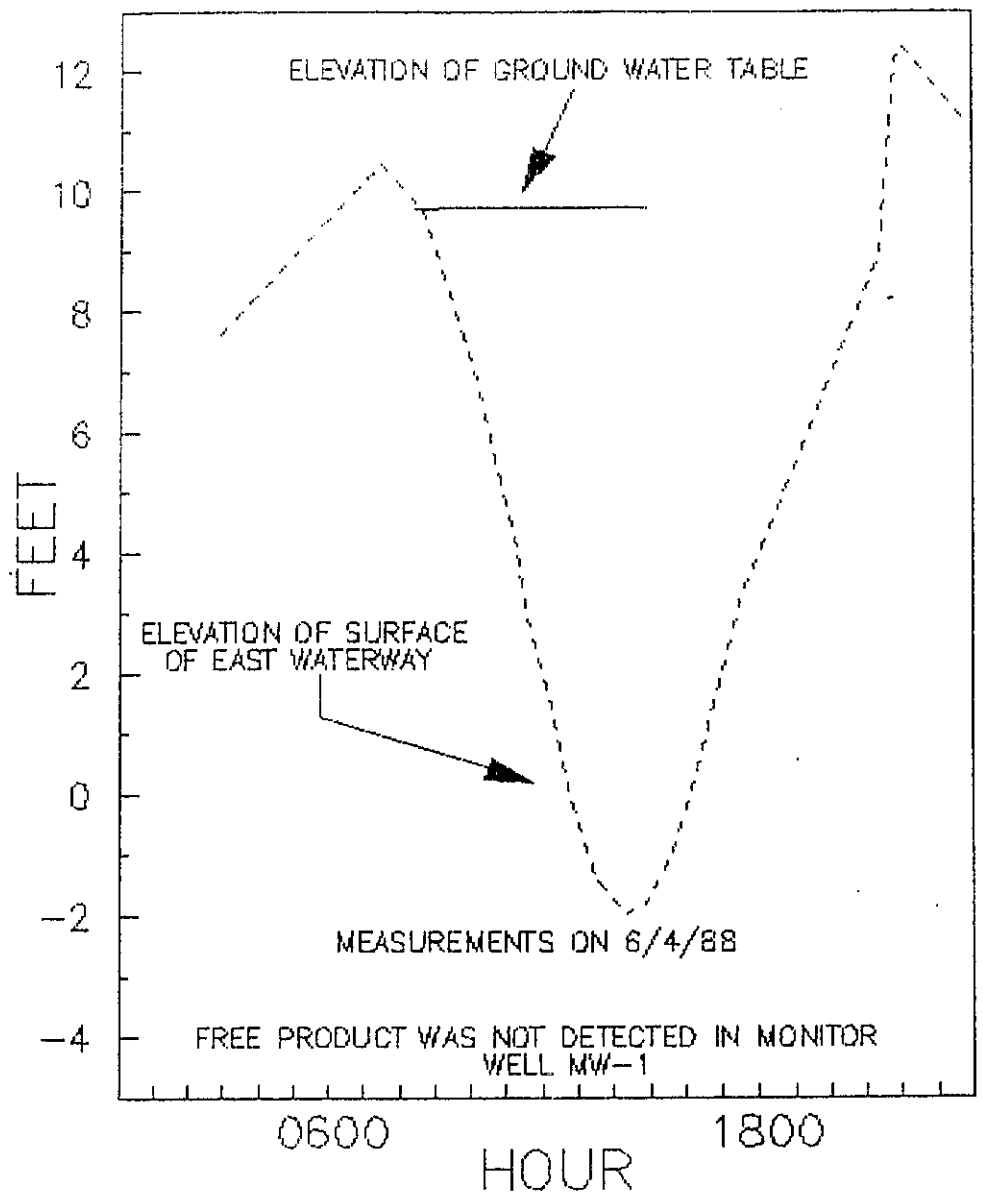
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-1

FIGURE A-21

0505-24-4 JHB:KK1 5-1/-88

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–1



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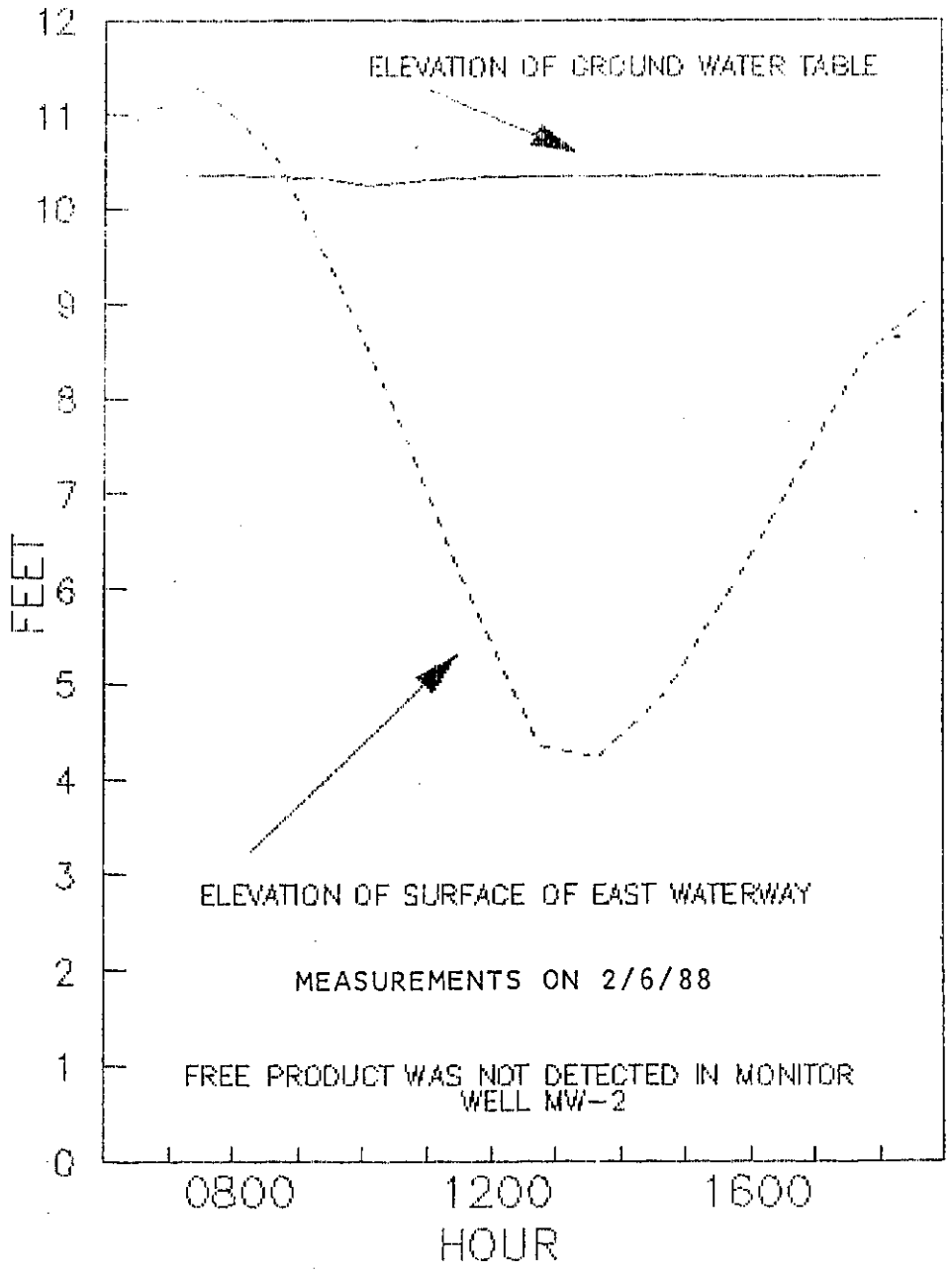
PLOT OF WATER ELEVATIONS– MONITOR WELL MW– 1

FIGURE A–22

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW-2



0303-24-4 JIB:KKT 3-17-88

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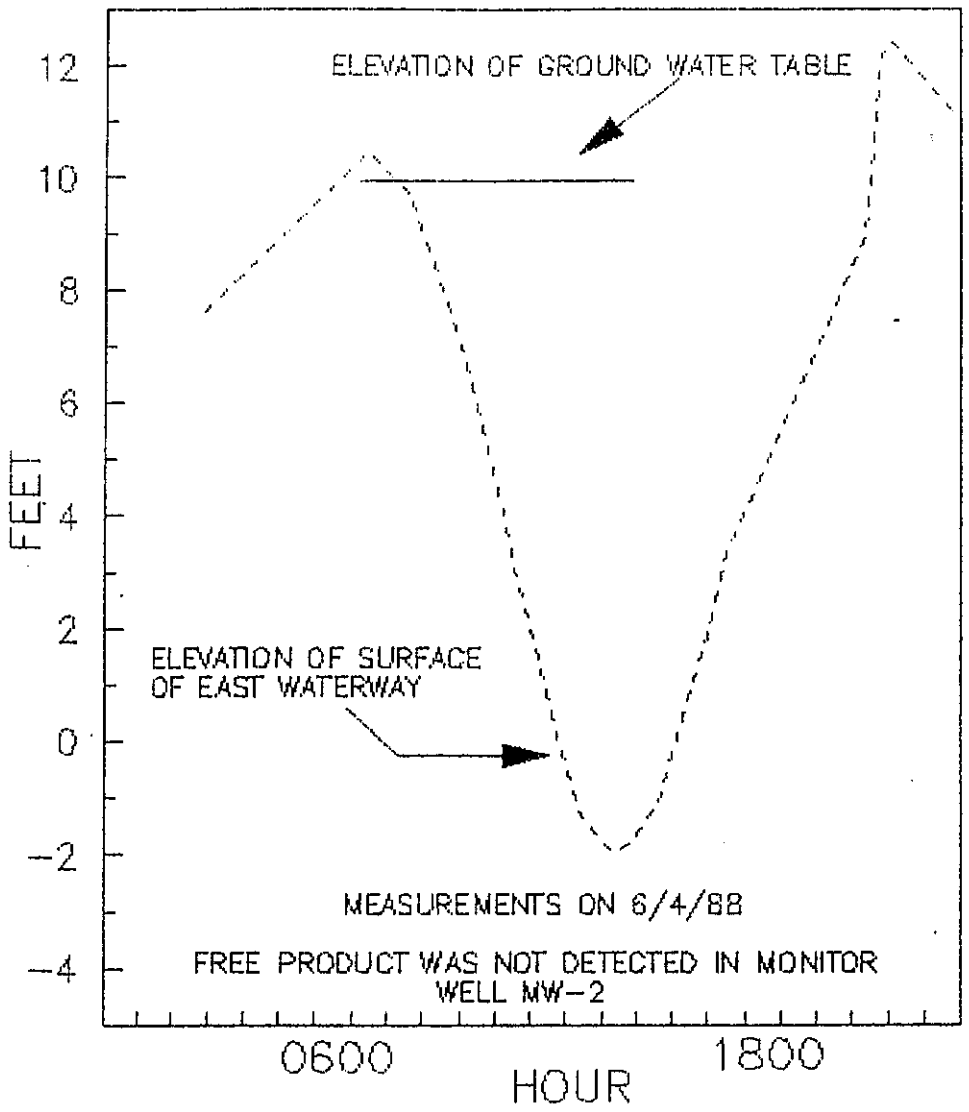
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-2

FIGURE A-23

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–2



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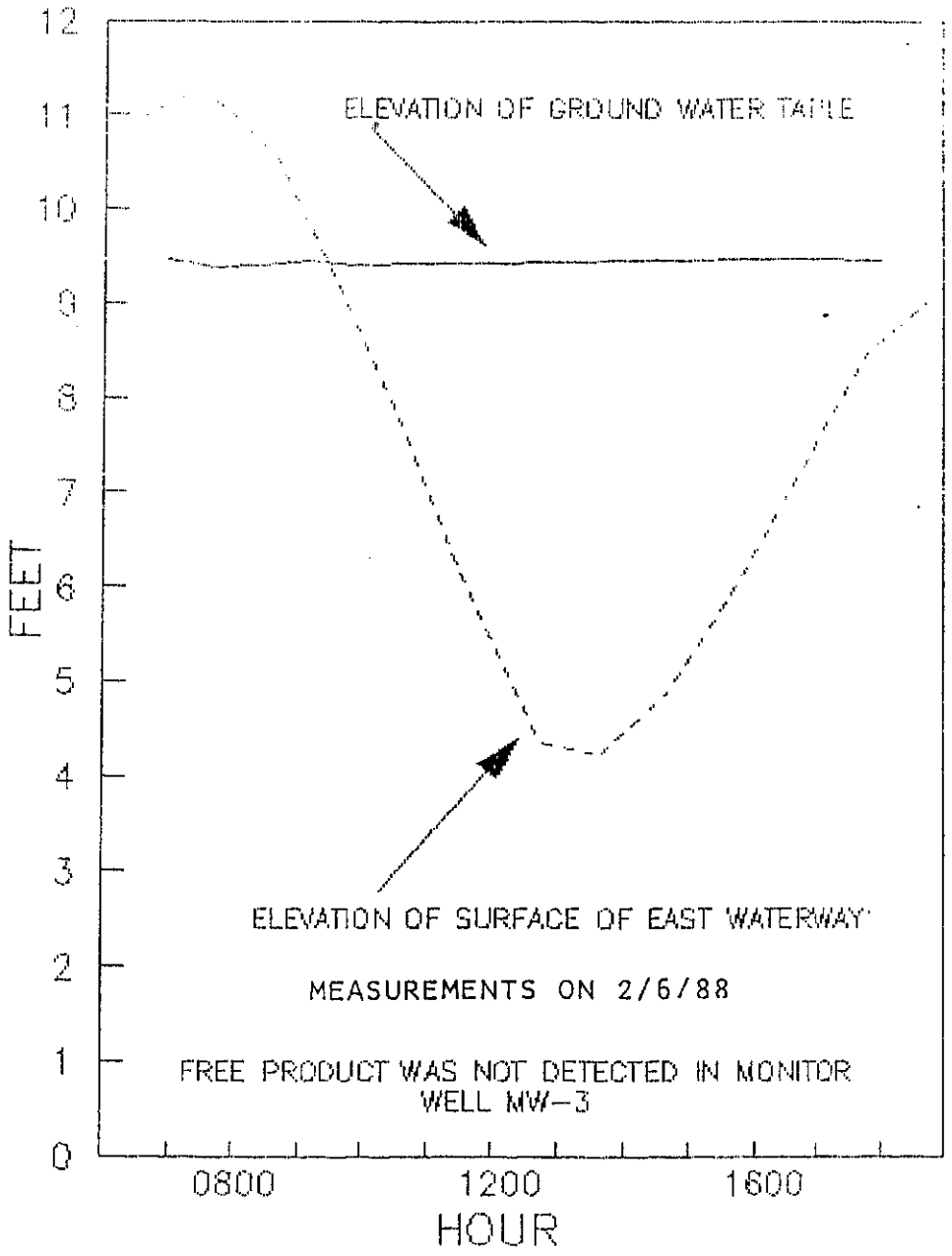
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-2

FIGURE A-24

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–3



0303-24-4 JHB:KKT 3-17-88

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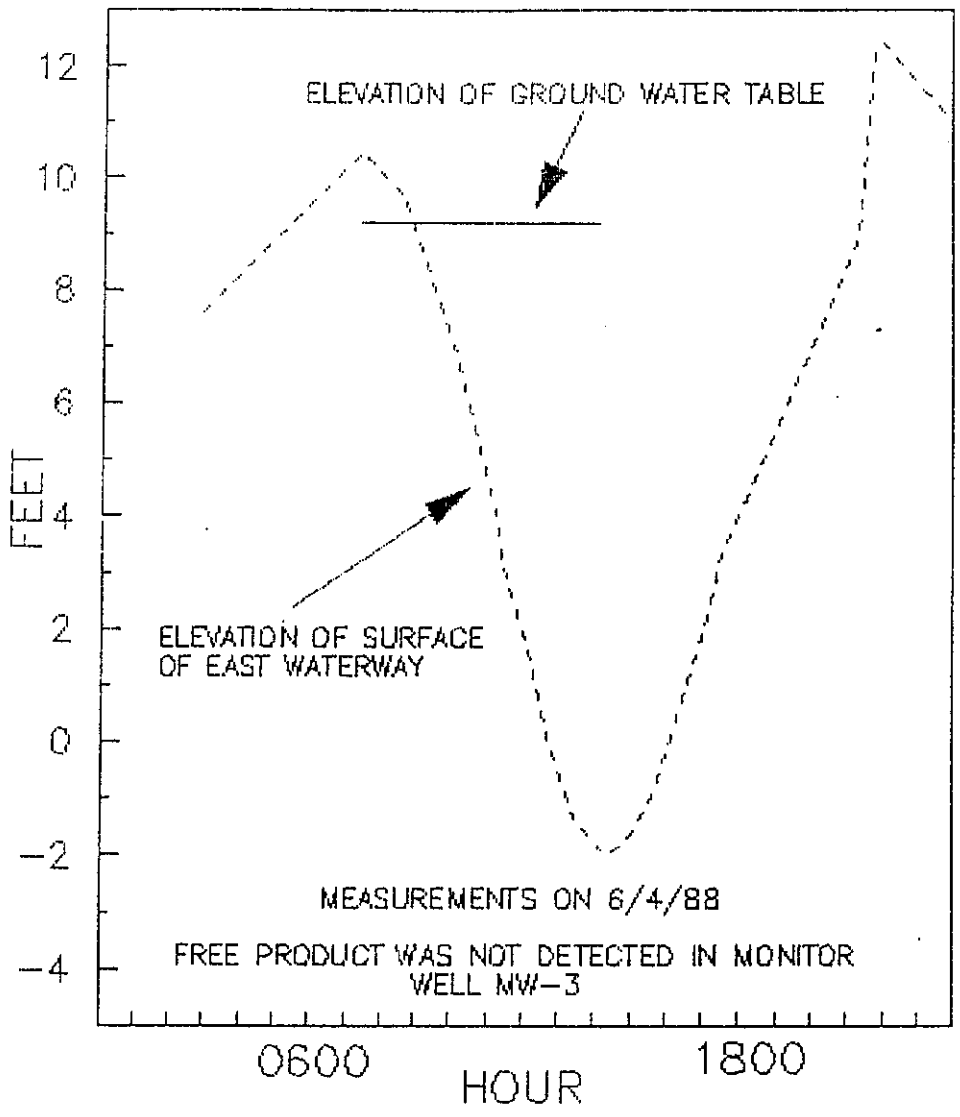
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-3

FIGURE A-25

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–3



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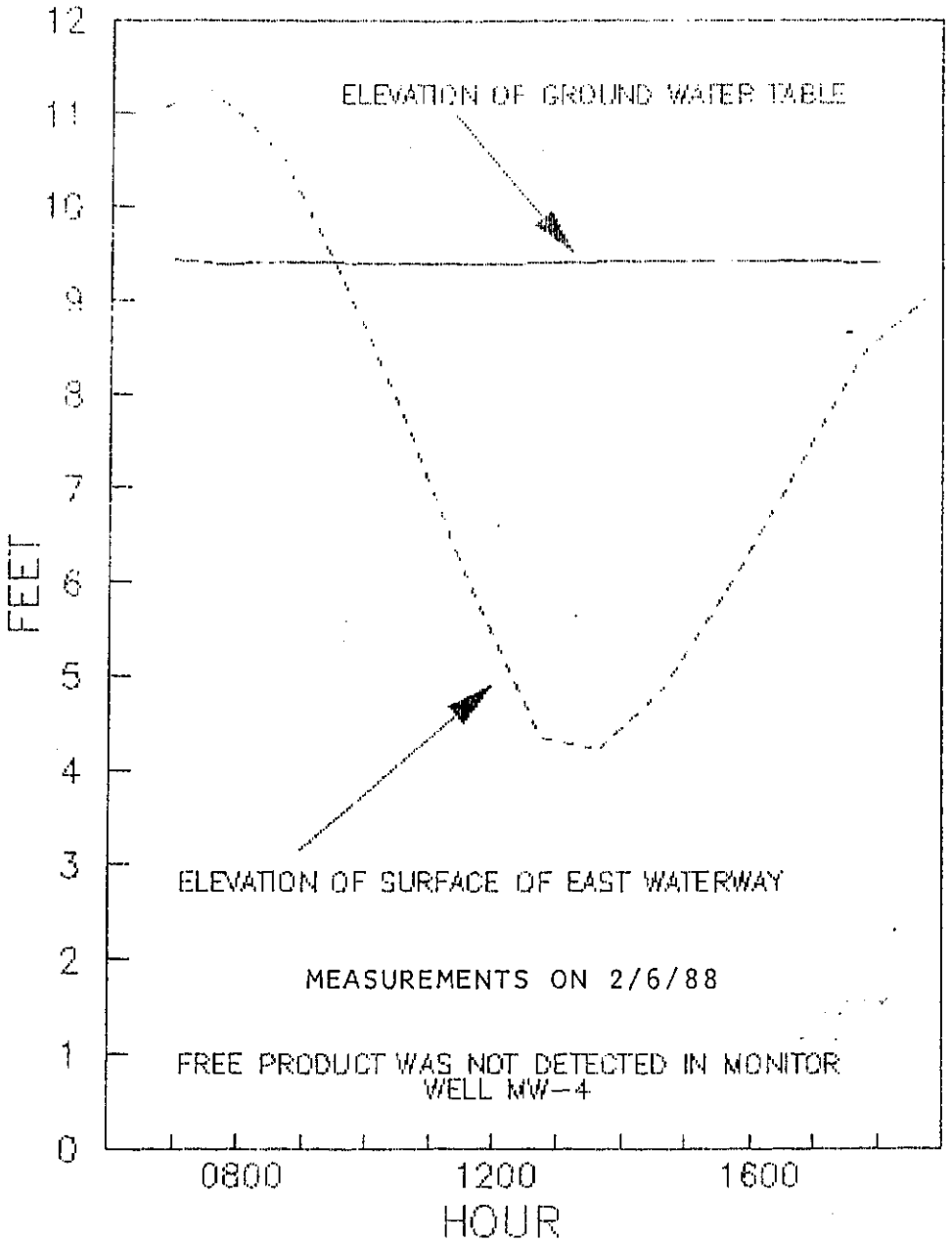
**PLOT OF WATER ELEVATIONS–
MONITOR WELL MW–3**

FIGURE A–26

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–4



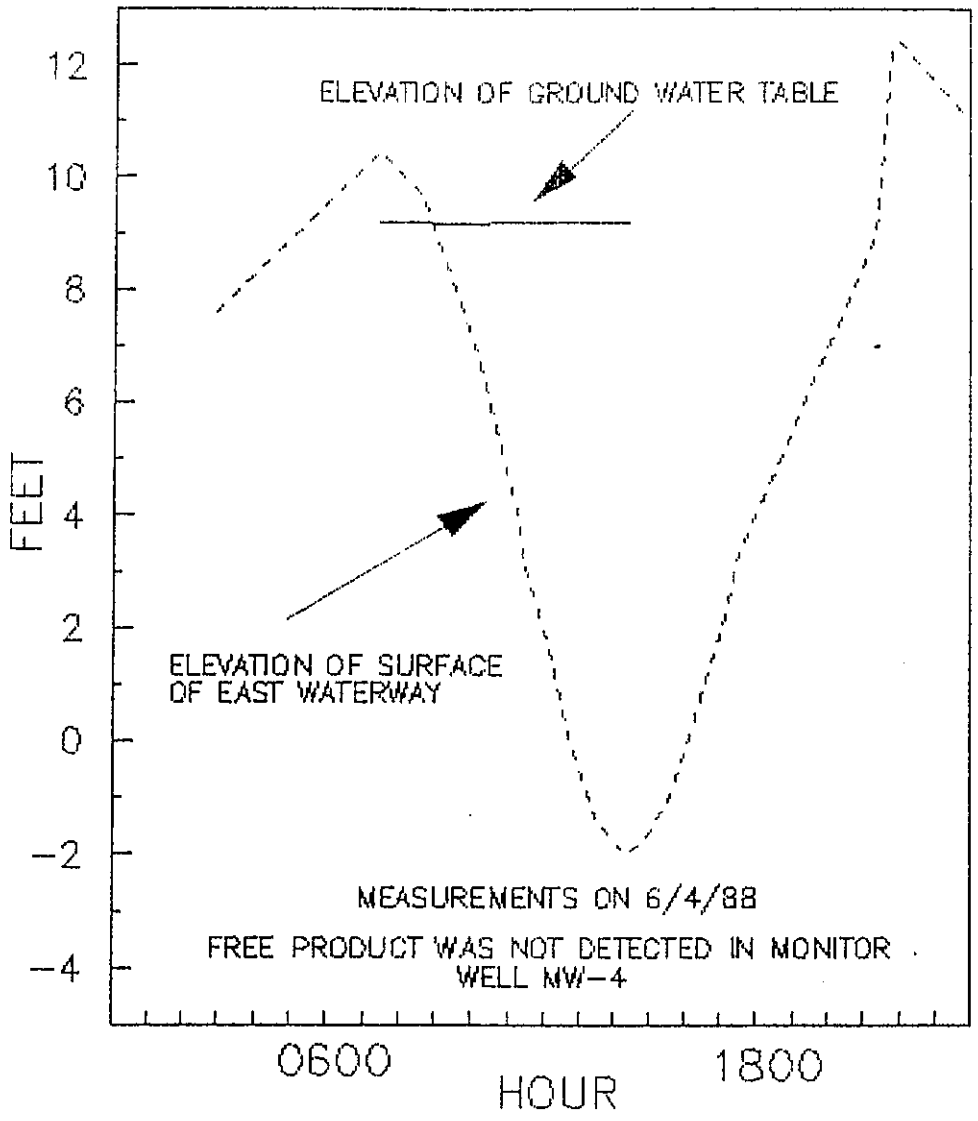
0303-24-4 JHB:KKT 3-17-88

GeoEngineers Incorporated

PLOT OF WATER ELEVATIONS-MONITOR WELL MW-4

FIGURE A-27

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–4

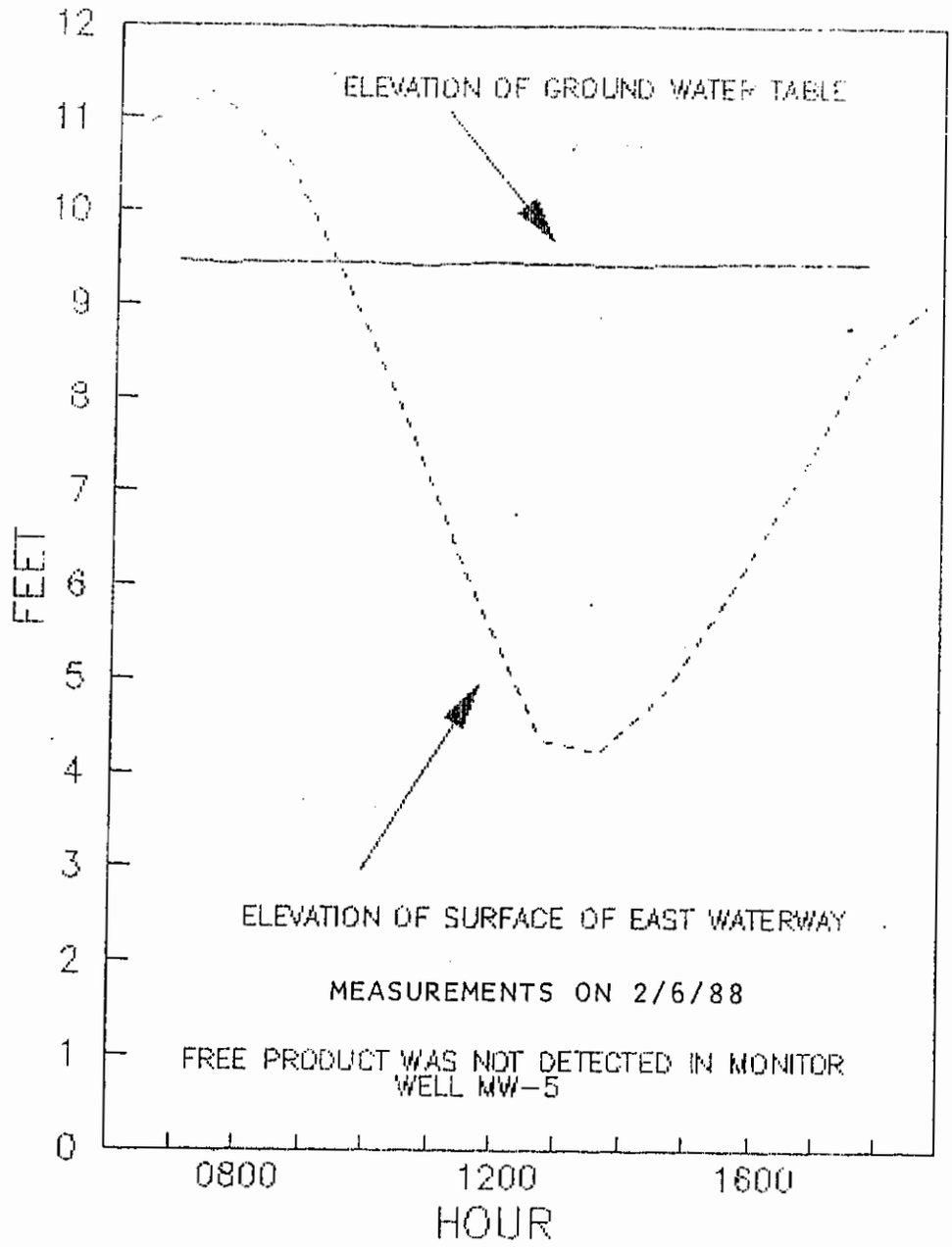


Geo Engineers

**PLOT OF WATER ELEVATIONS–
MONITOR WELL MW–4**

FIGURE A–28

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–5



0303-24-4 JHB:KKT 3-17-88

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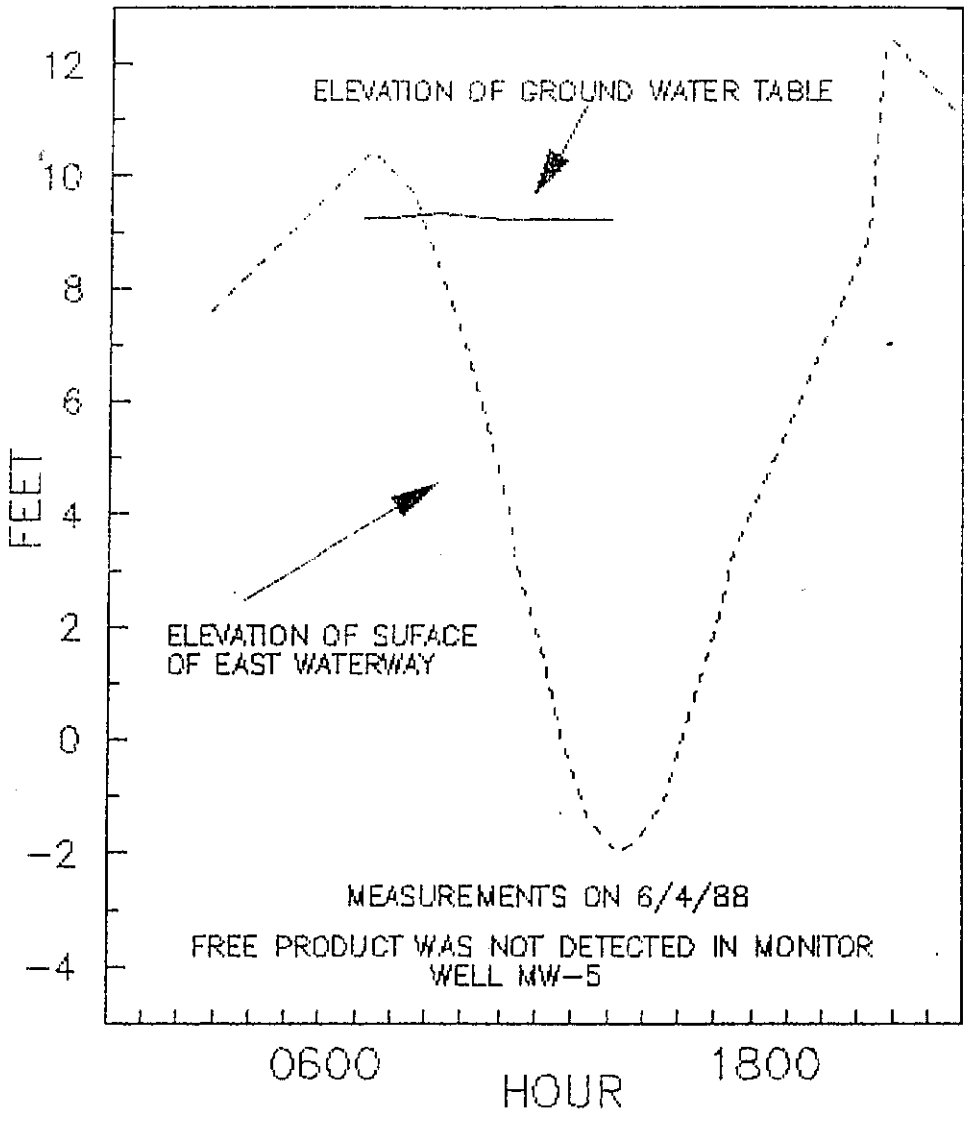
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-5

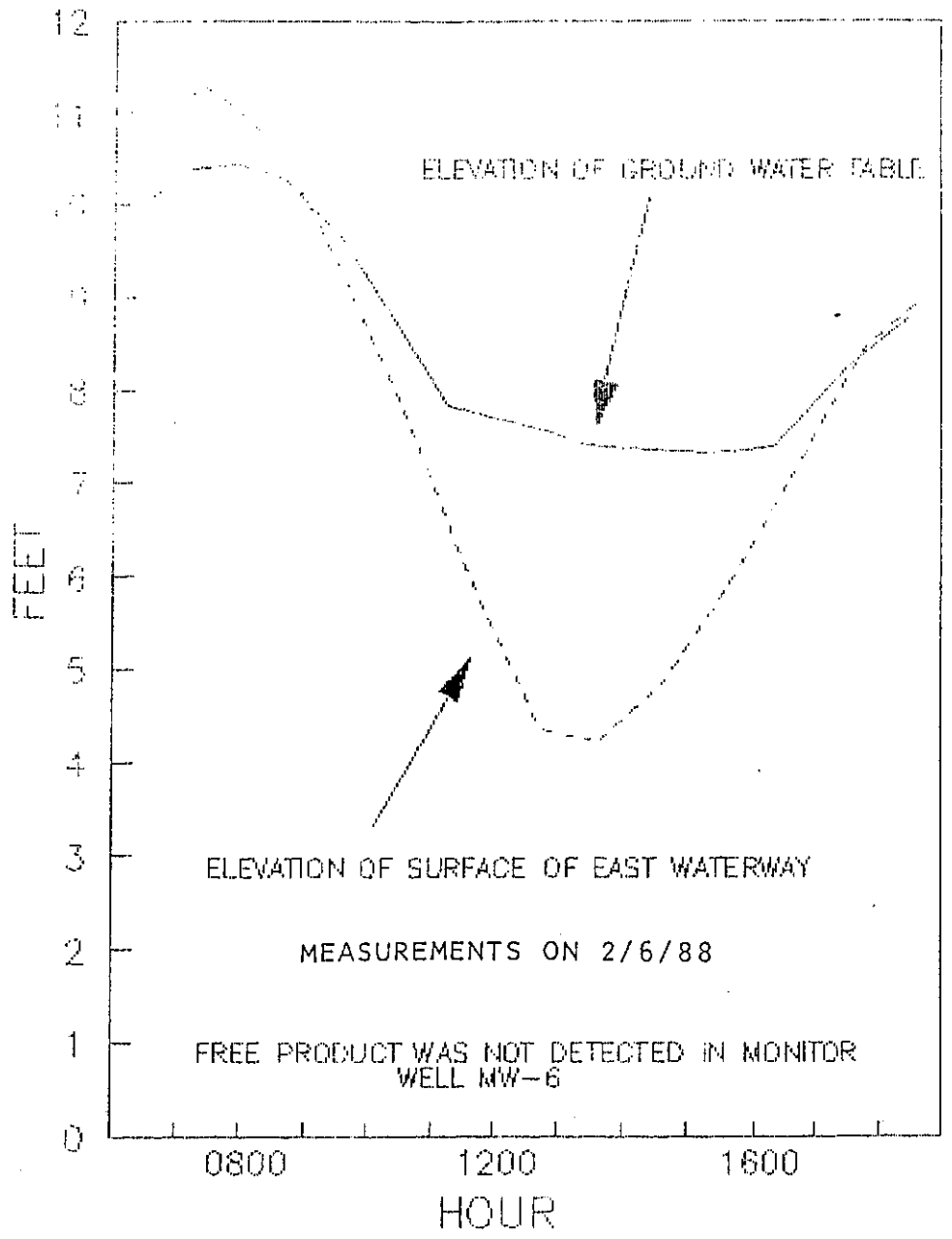
FIGURE A-29

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–5



GeoEngineers	**PLOT OF WATER ELEVATIONS– MONITOR WELL MW– 5**
	FIGURE A-30

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–6



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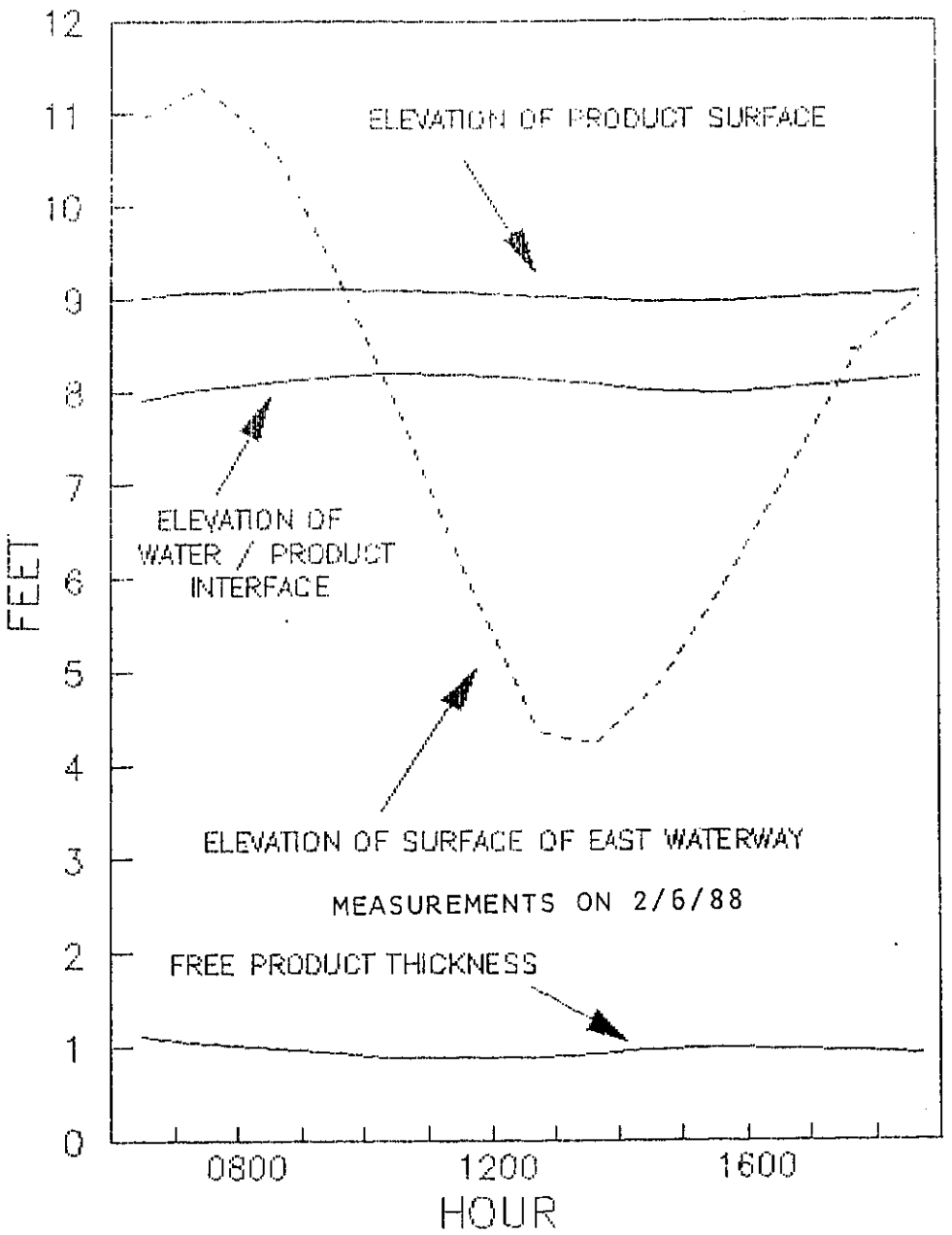
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-6

FIGURE A-31

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW-7



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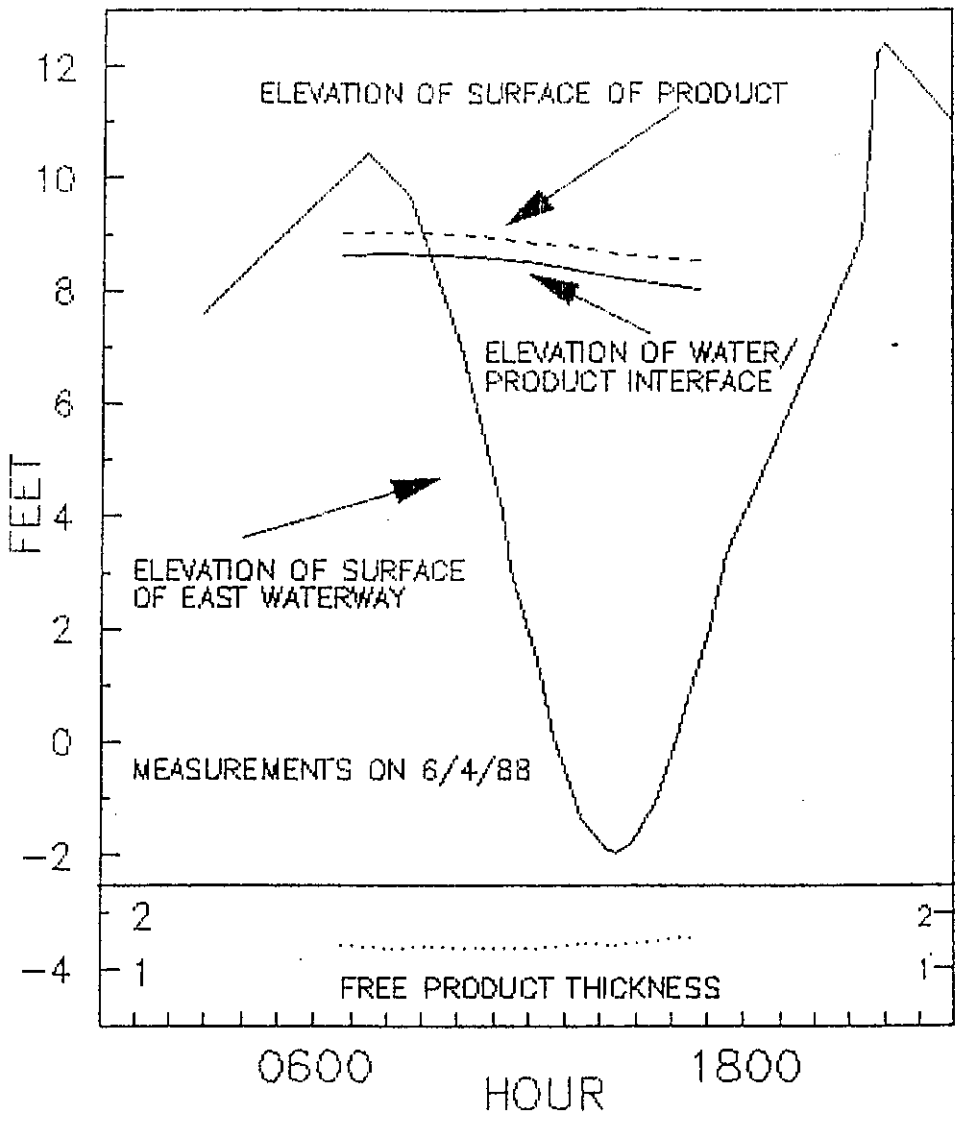
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-7

FIGURE A-32

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–7



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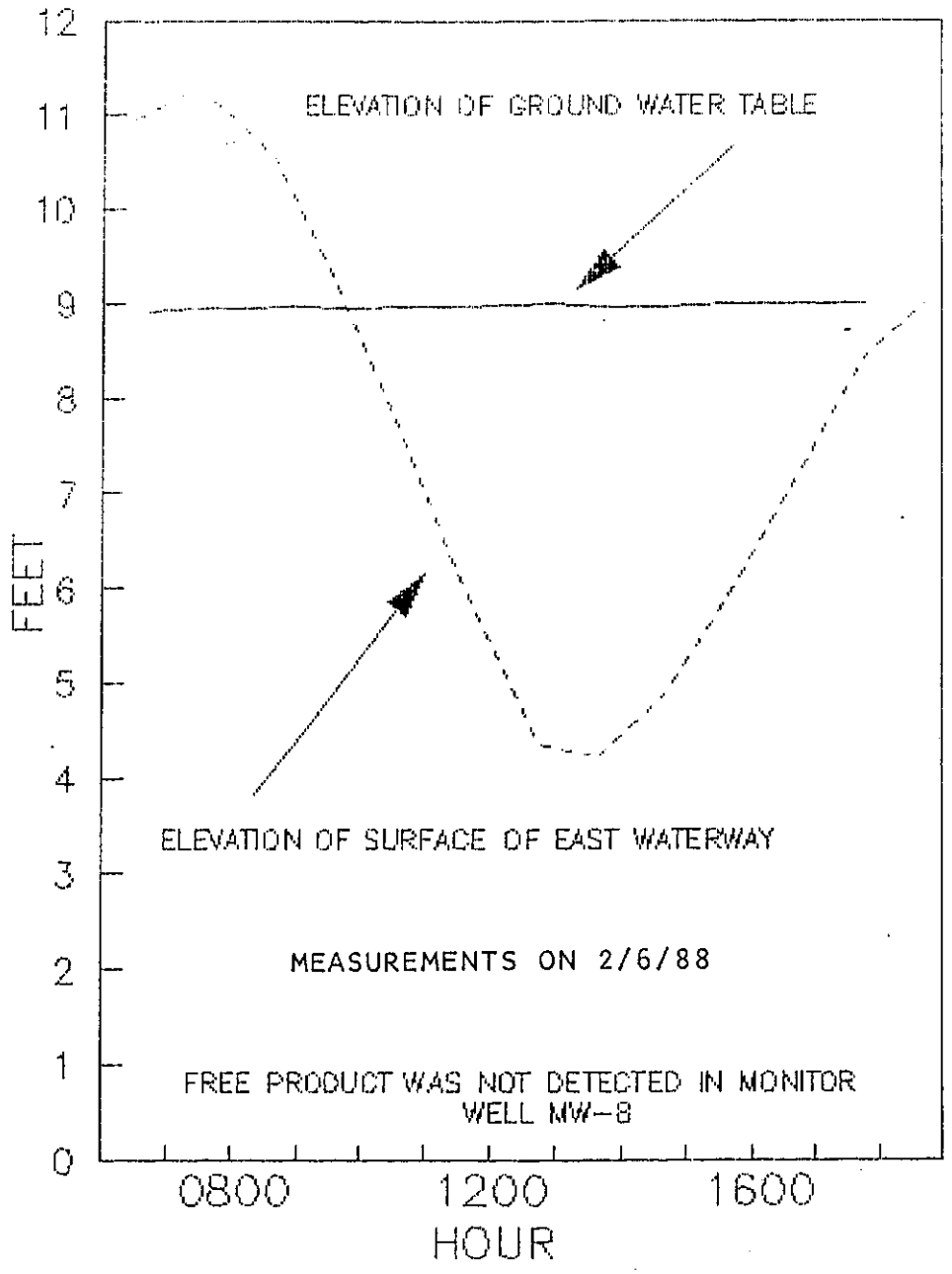
**PLOT OF WATER ELEVATIONS–
MONITOR WELL MW–7**

FIGURE A-33

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–8



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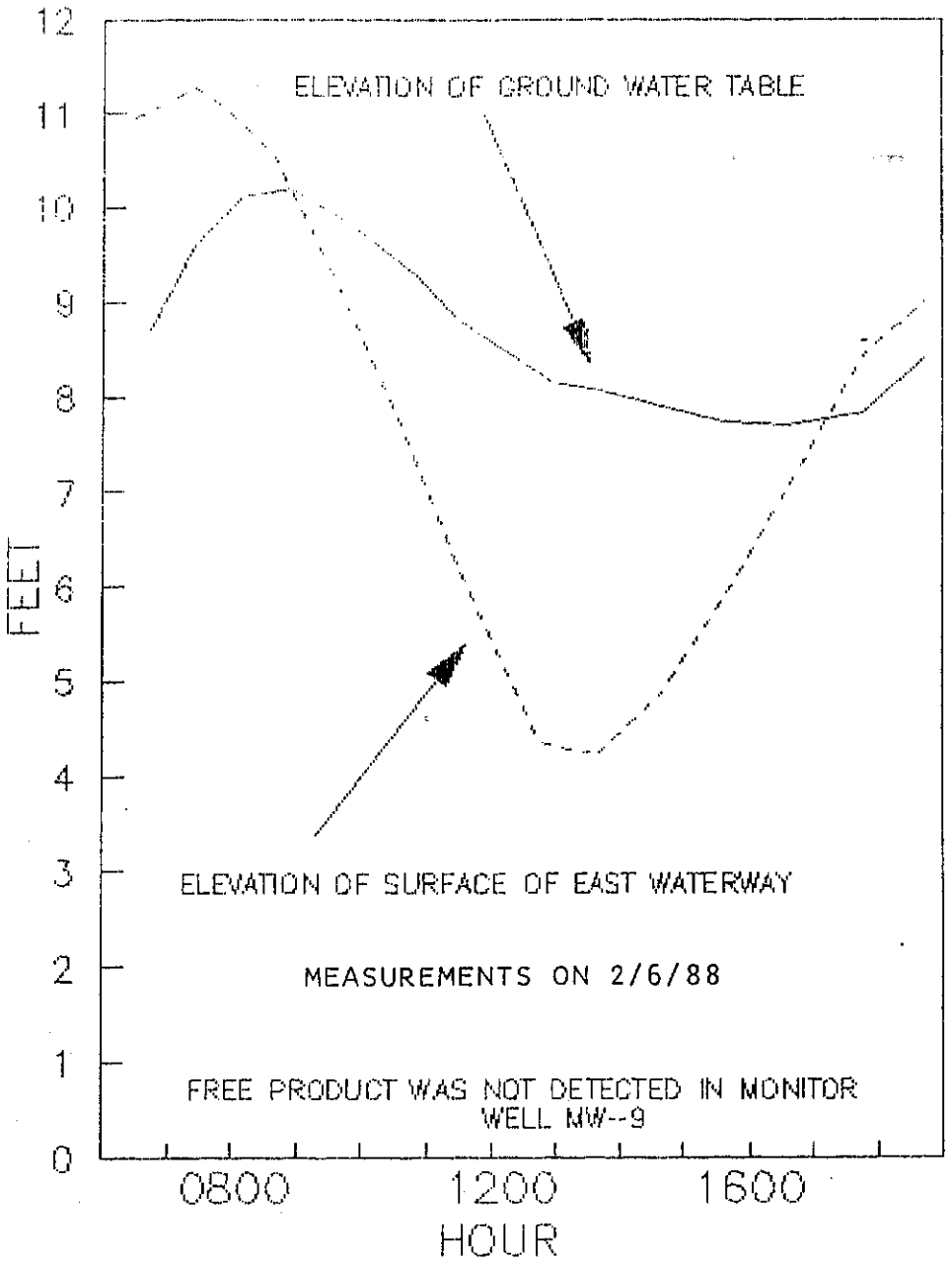
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-8

FIGURE A-34

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–9



0303-24-4 JHB:KKT 3-17-88

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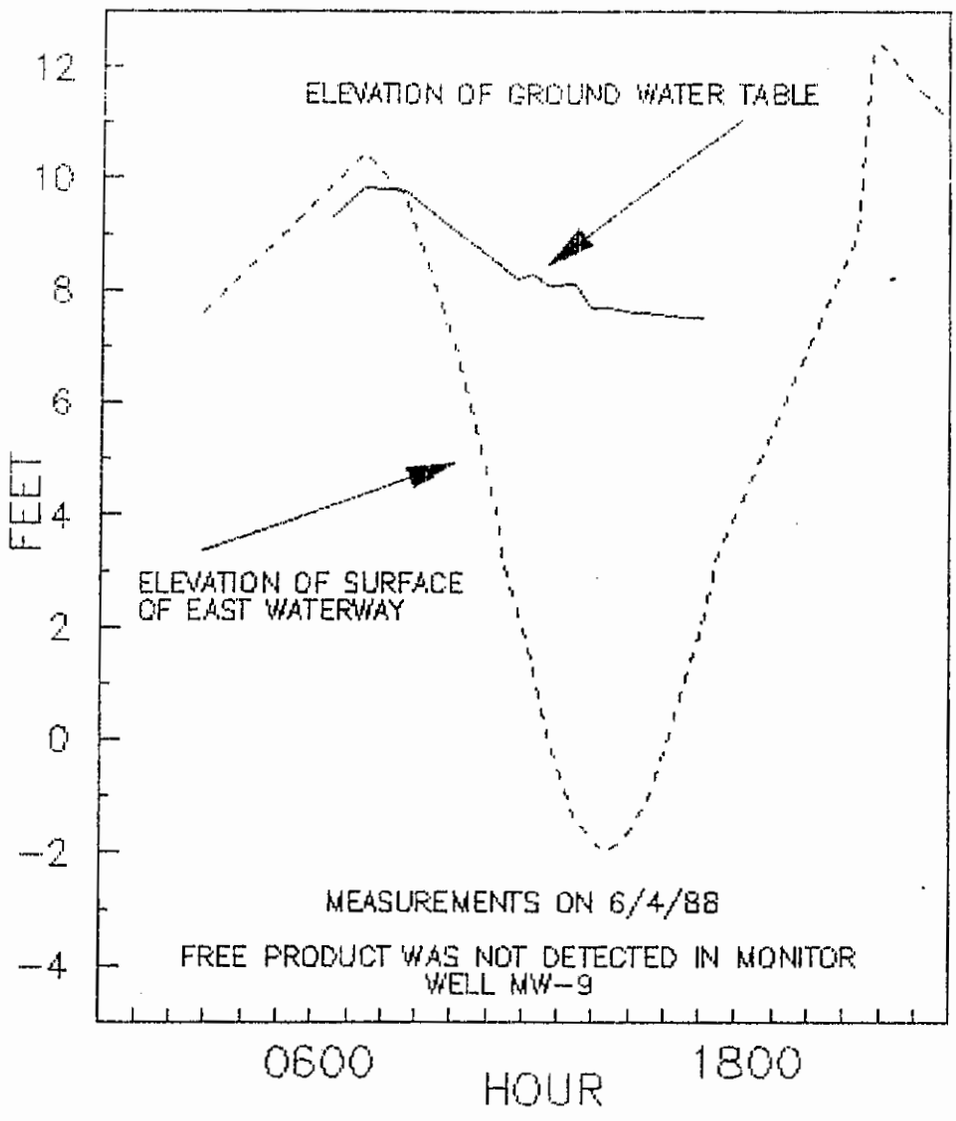
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-9

FIGURE A-35

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–9



G303-24-4 WASKNT 7-18-88

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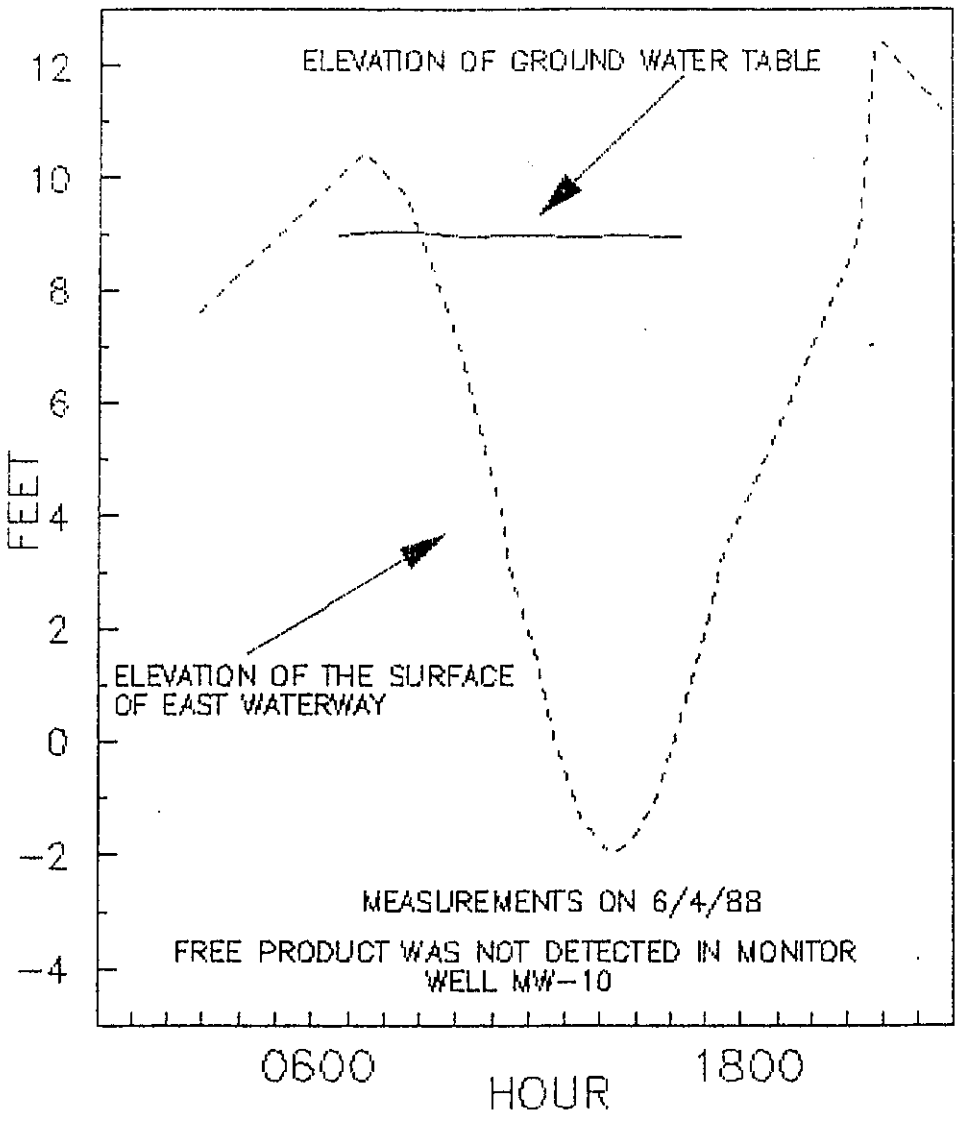
**PLOT OF WATER ELEVATIONS–
MONITOR WELL MW–9**

FIGURE A-36

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–10

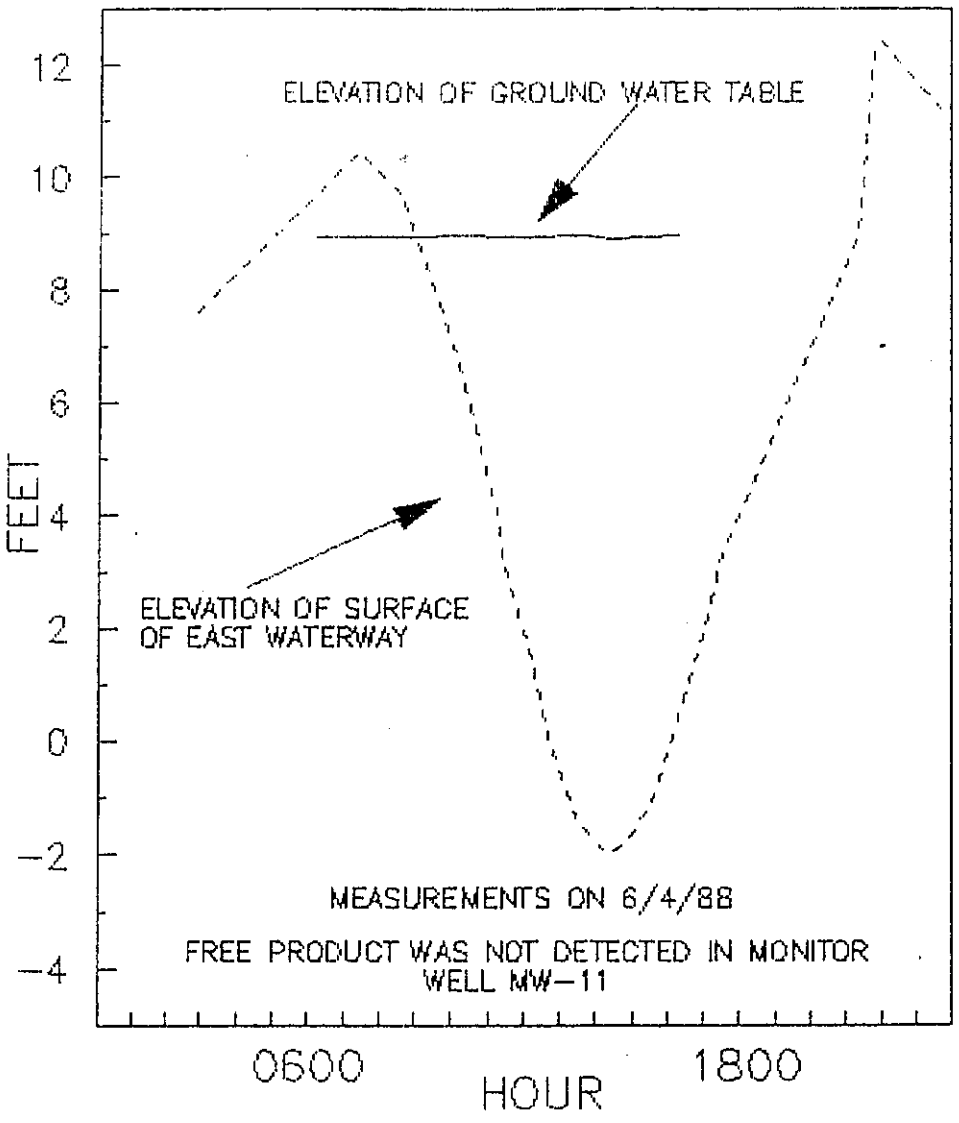


Geo Engineers

**PLOT OF WATER ELEVATIONS–
MONITOR WELL MW–10**

FIGURE A-37

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW-11

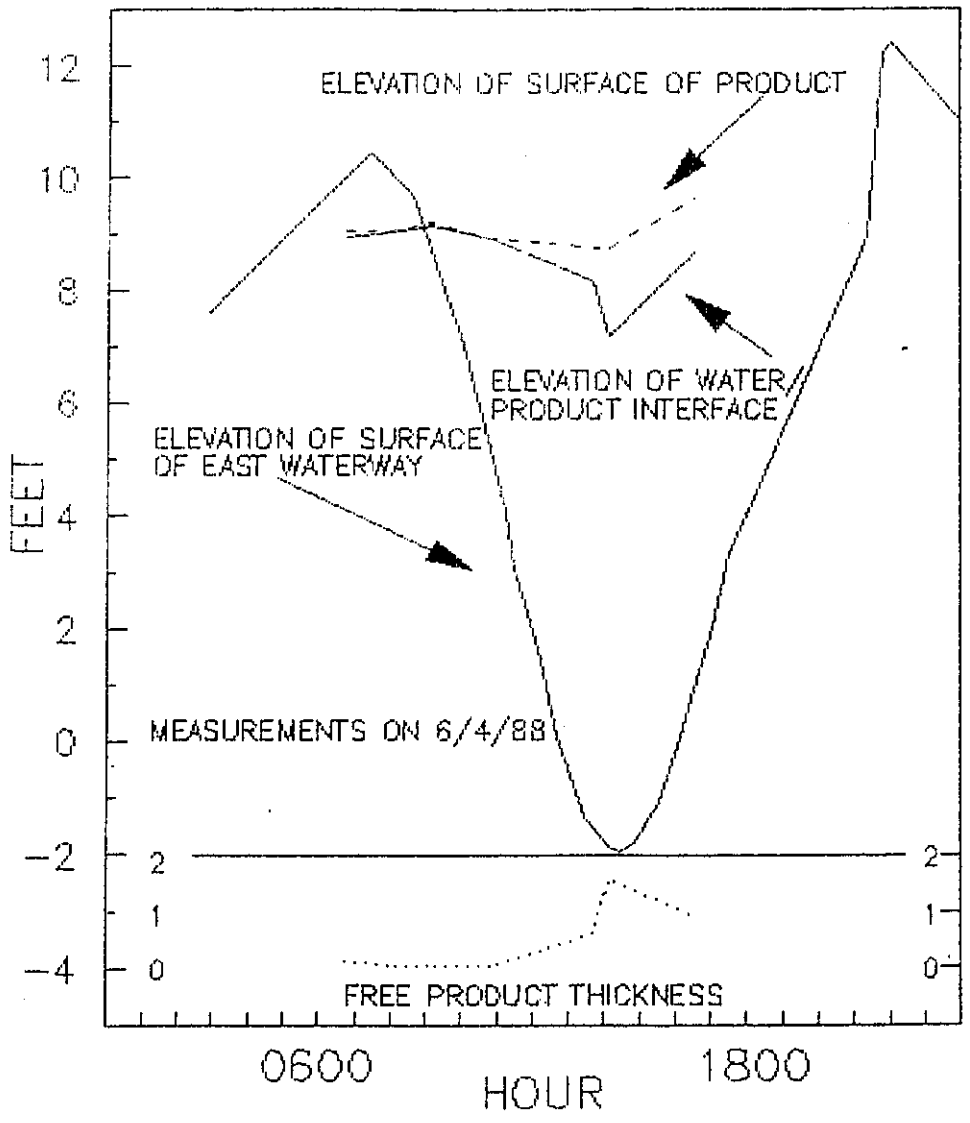


Geo Engineers

**PLOT OF WATER ELEVATIONS-
MONITOR WELL MW-11**

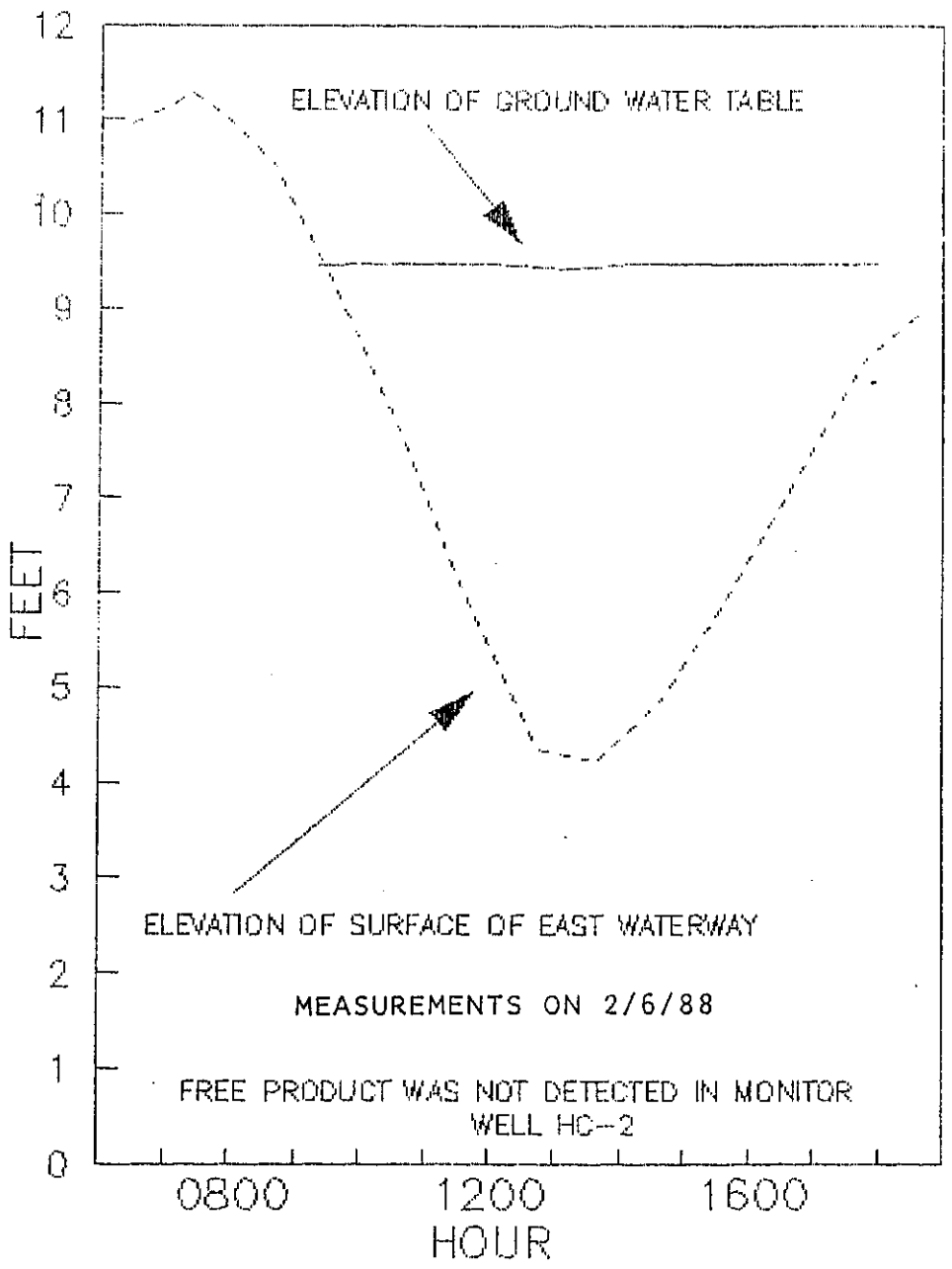
FIGURE A-38

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–12



GeoEngineers	**PLOT OF WATER ELEVATIONS– MONITOR WELL MW– 12**
	FIGURE A–39

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL HC–2



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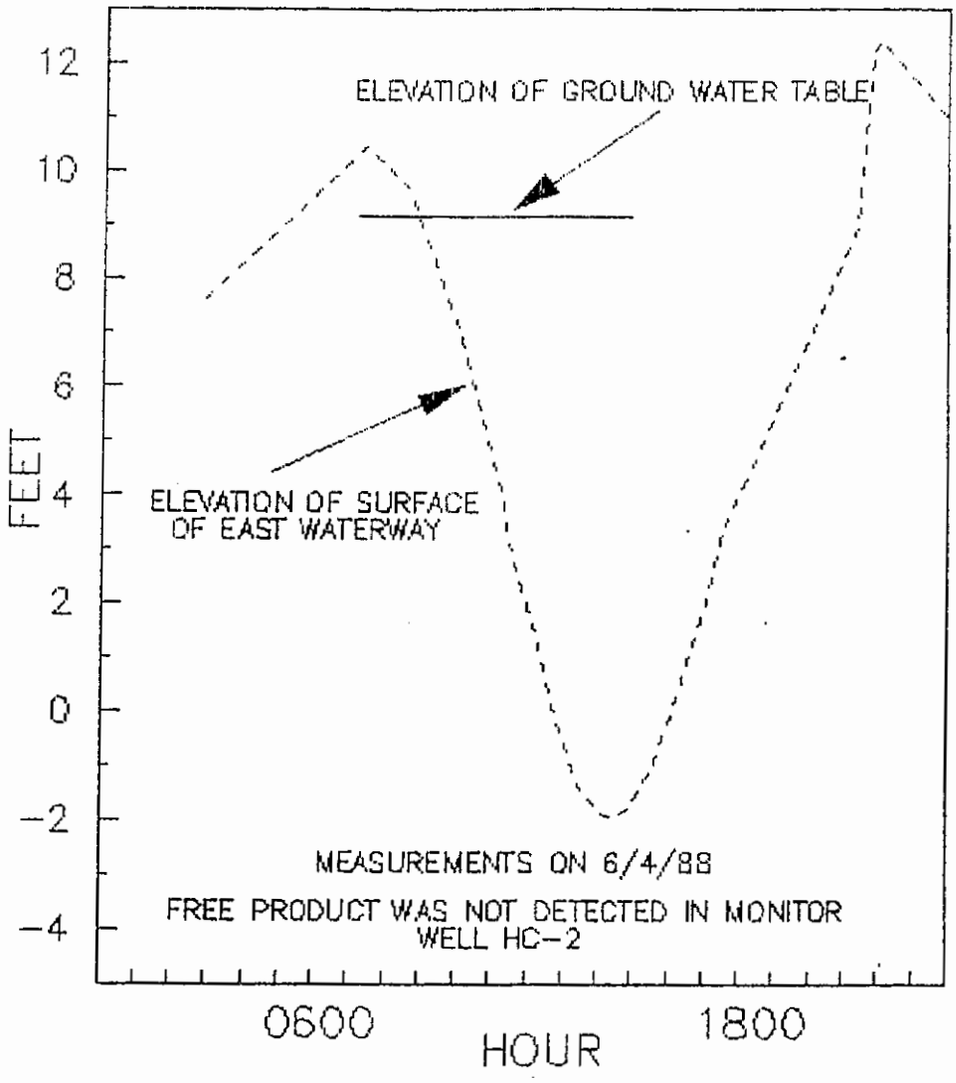
PLOT OF WATER ELEVATIONS-MONITOR WELL HC-2

FIGURE A-40

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL HC–2



0303-241 JHB KKT 7/18/88

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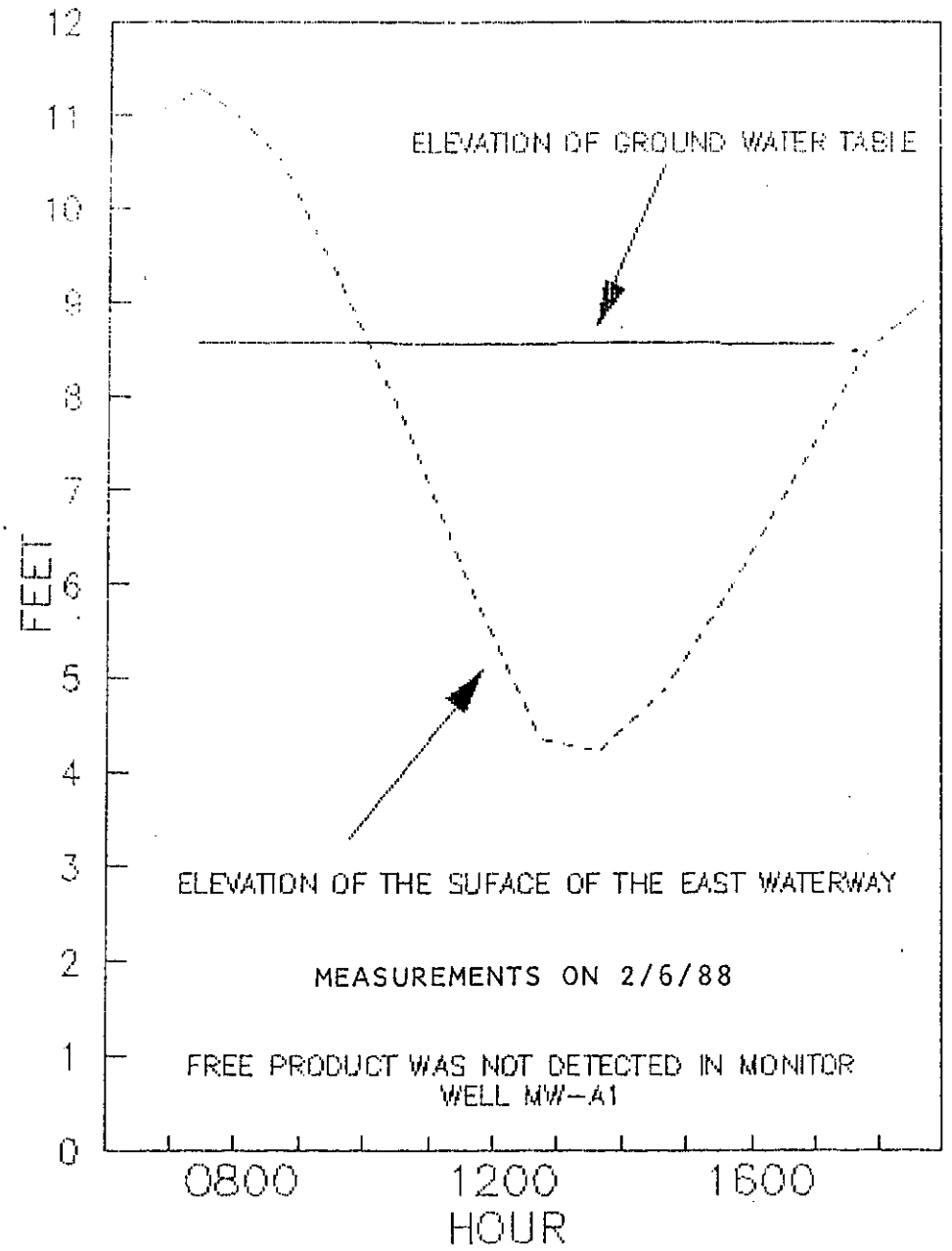
**PLOT OF WATER ELEVATIONS-
MONITOR WELL HC-2**

FIGURE A-41

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A1



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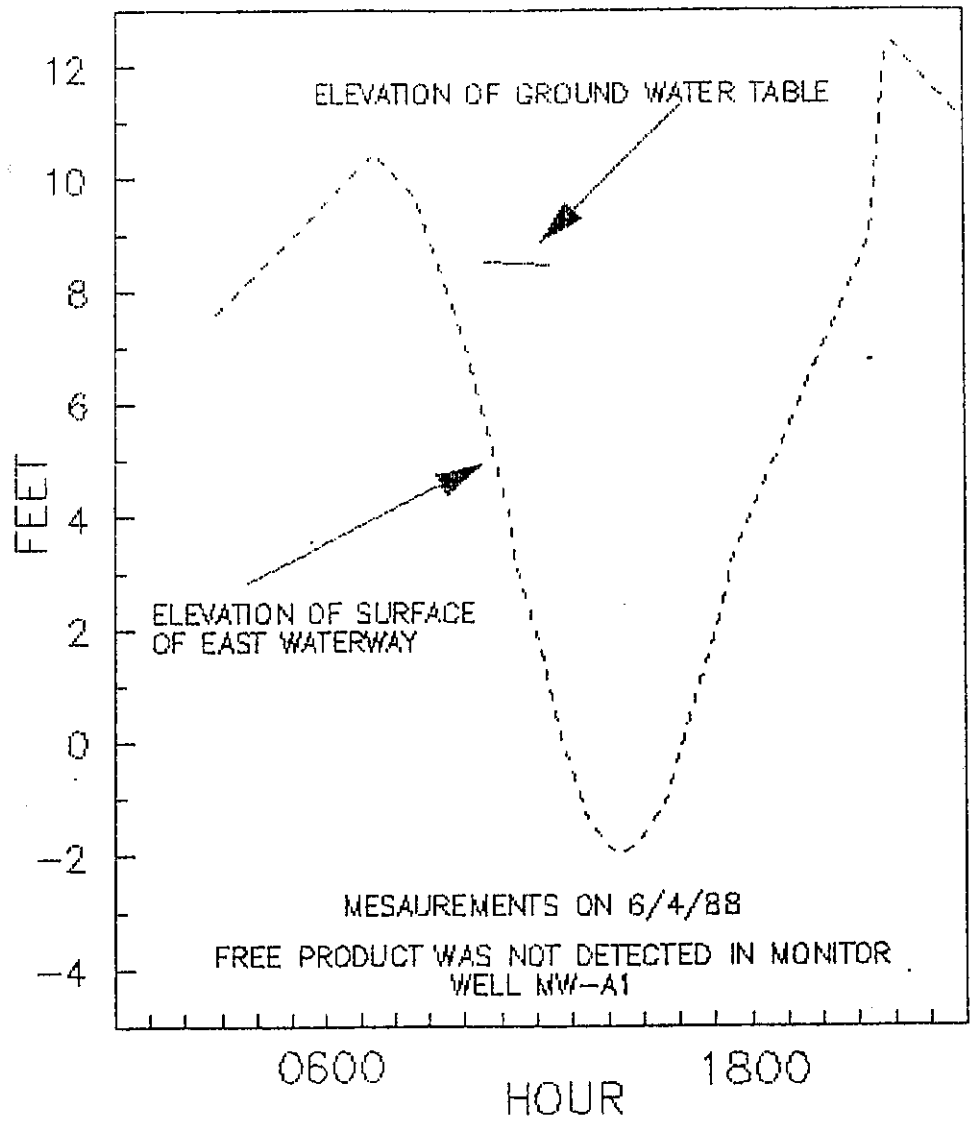
PLOT OF WATER ELEVATIONS- MONITOR WELL MW- A1

FIGURE A-42

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A1



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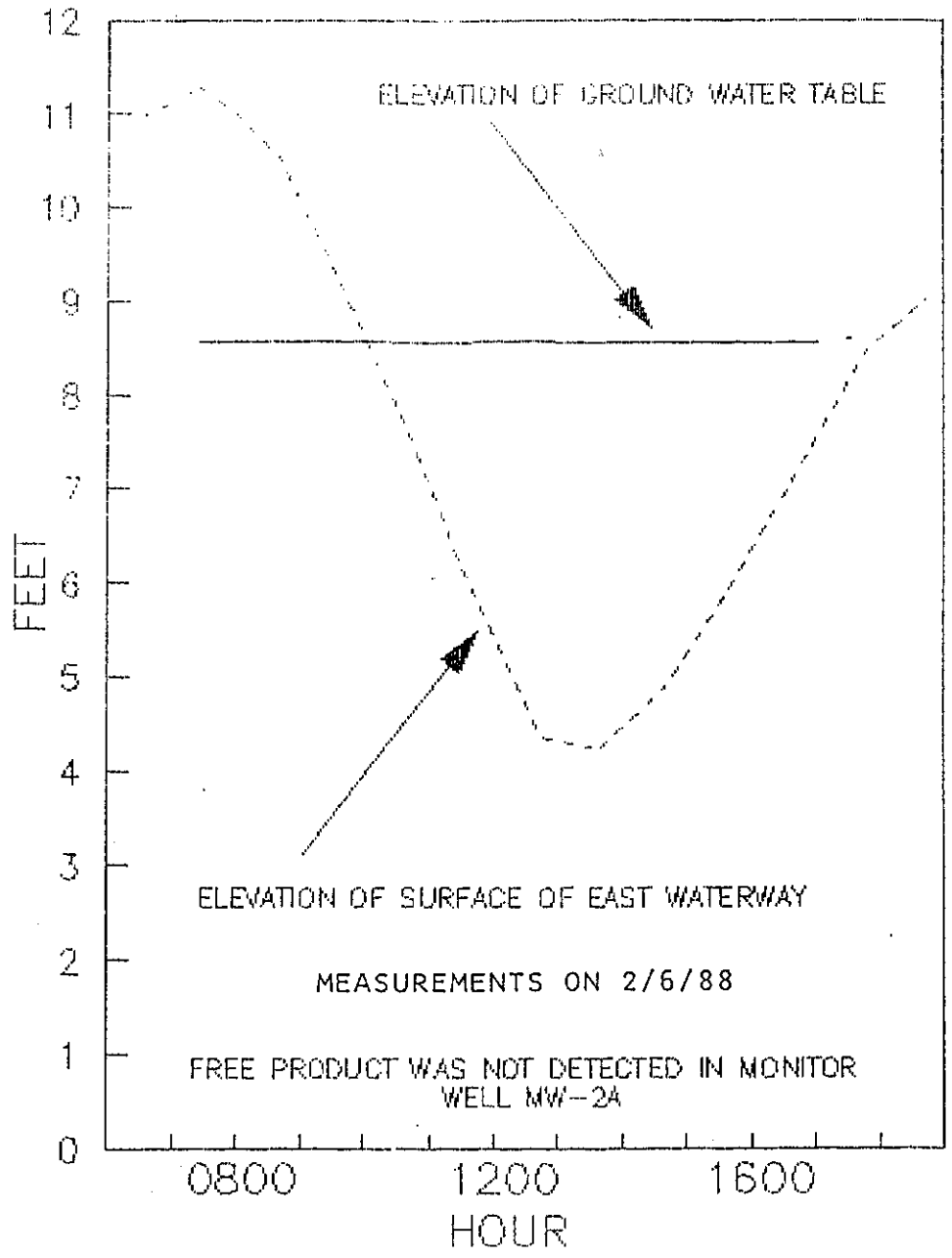
**PLOT OF WATER ELEVATIONS-
MONITOR WELL MW-A1**

FIGURE A-43

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A2



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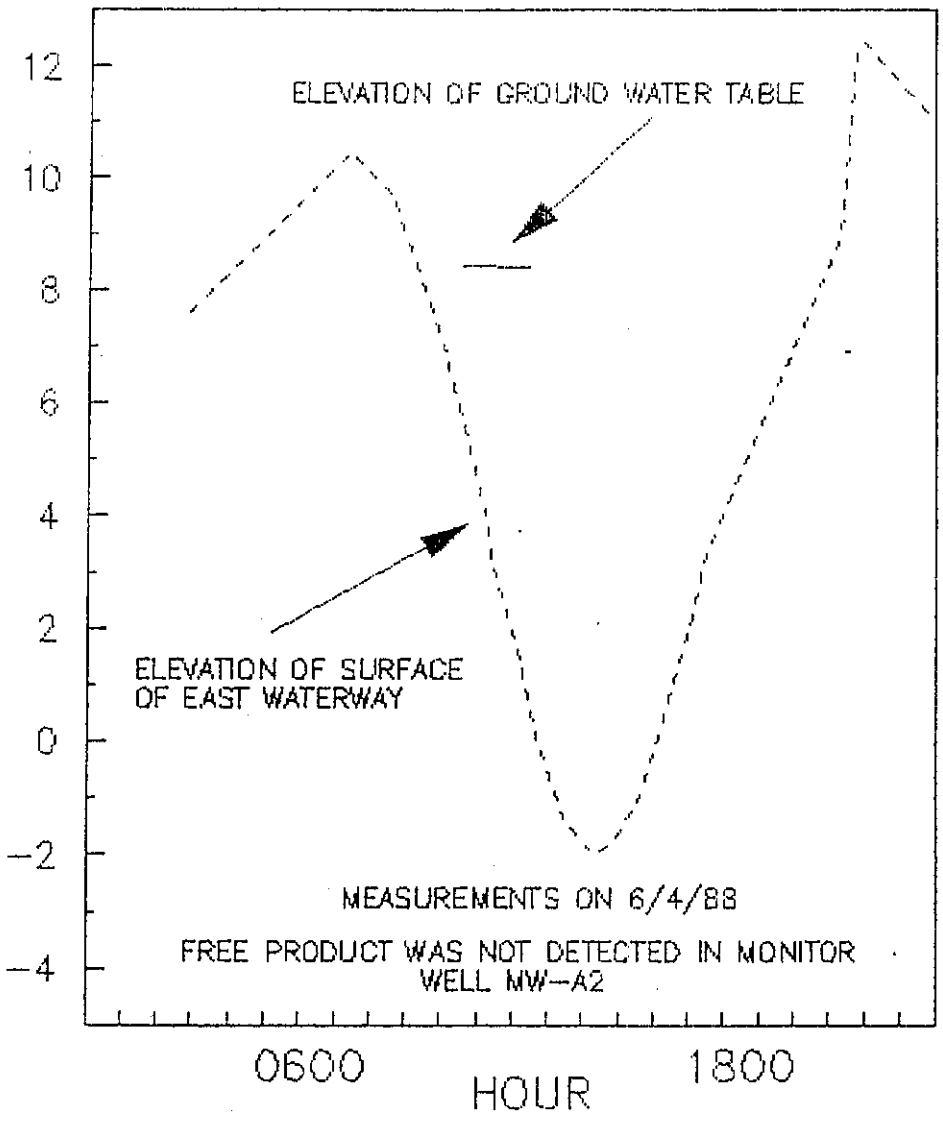
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-A2

FIGURE A-44

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A2



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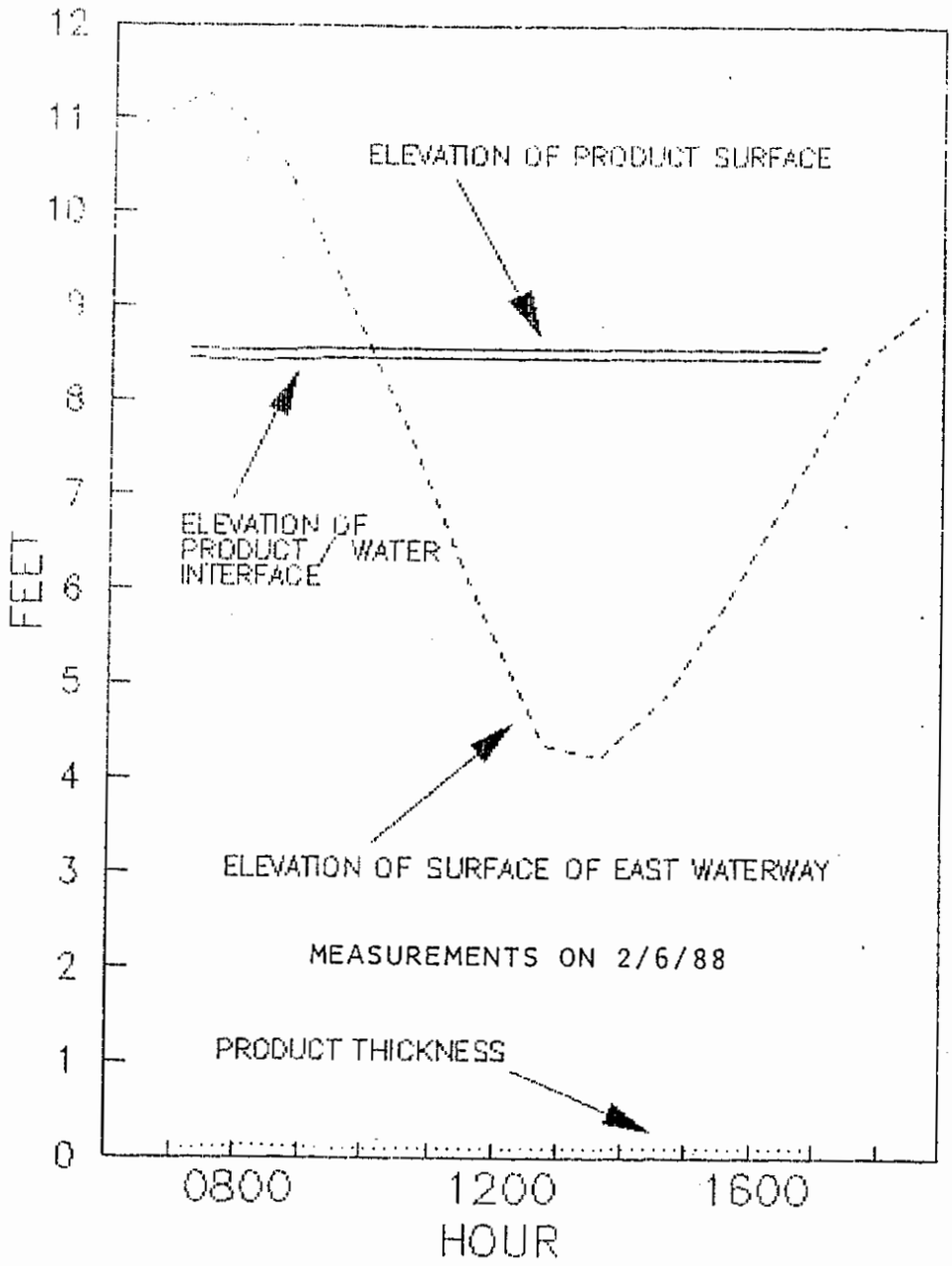
**PLOT OF WATER ELEVATIONS-
MONITOR WELL MW- A2**

FIGURE A-45

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A3



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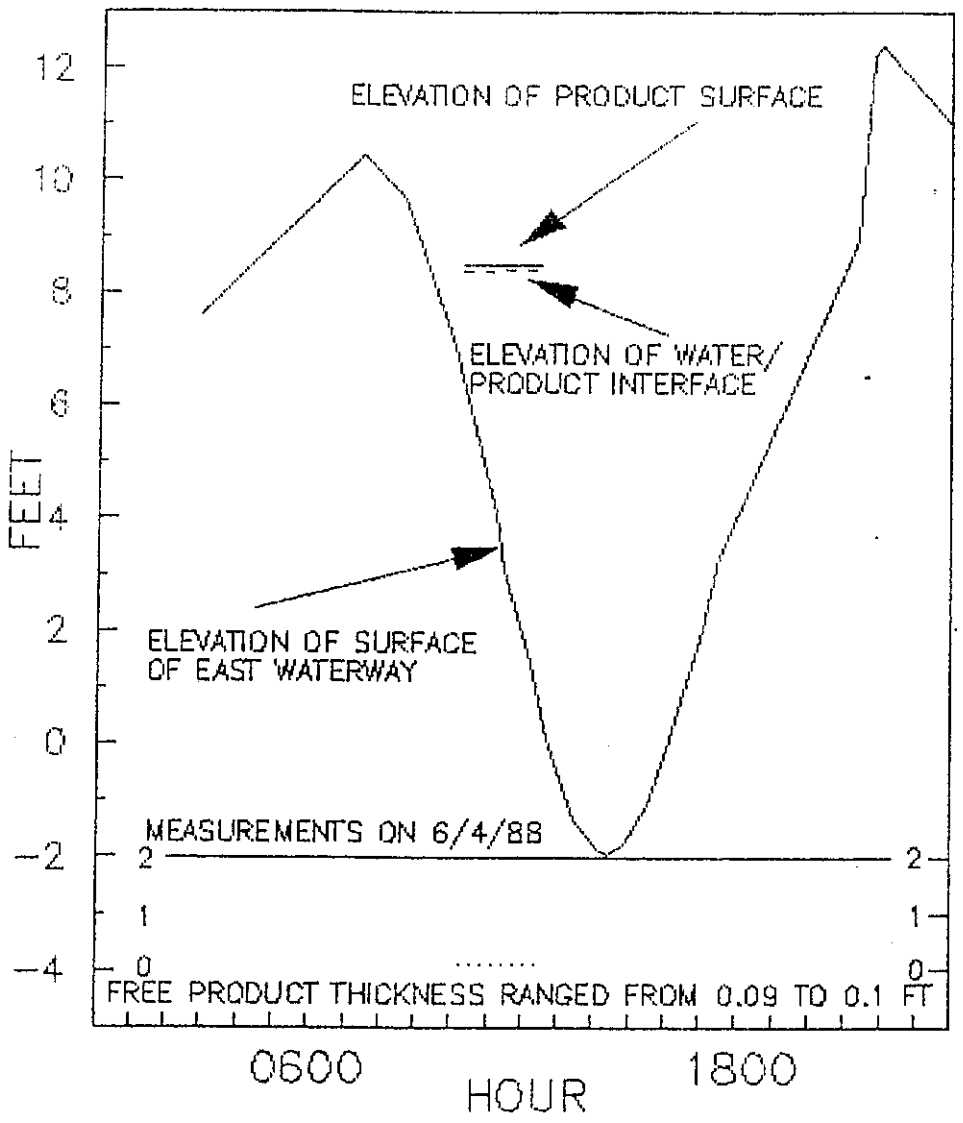
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-A3

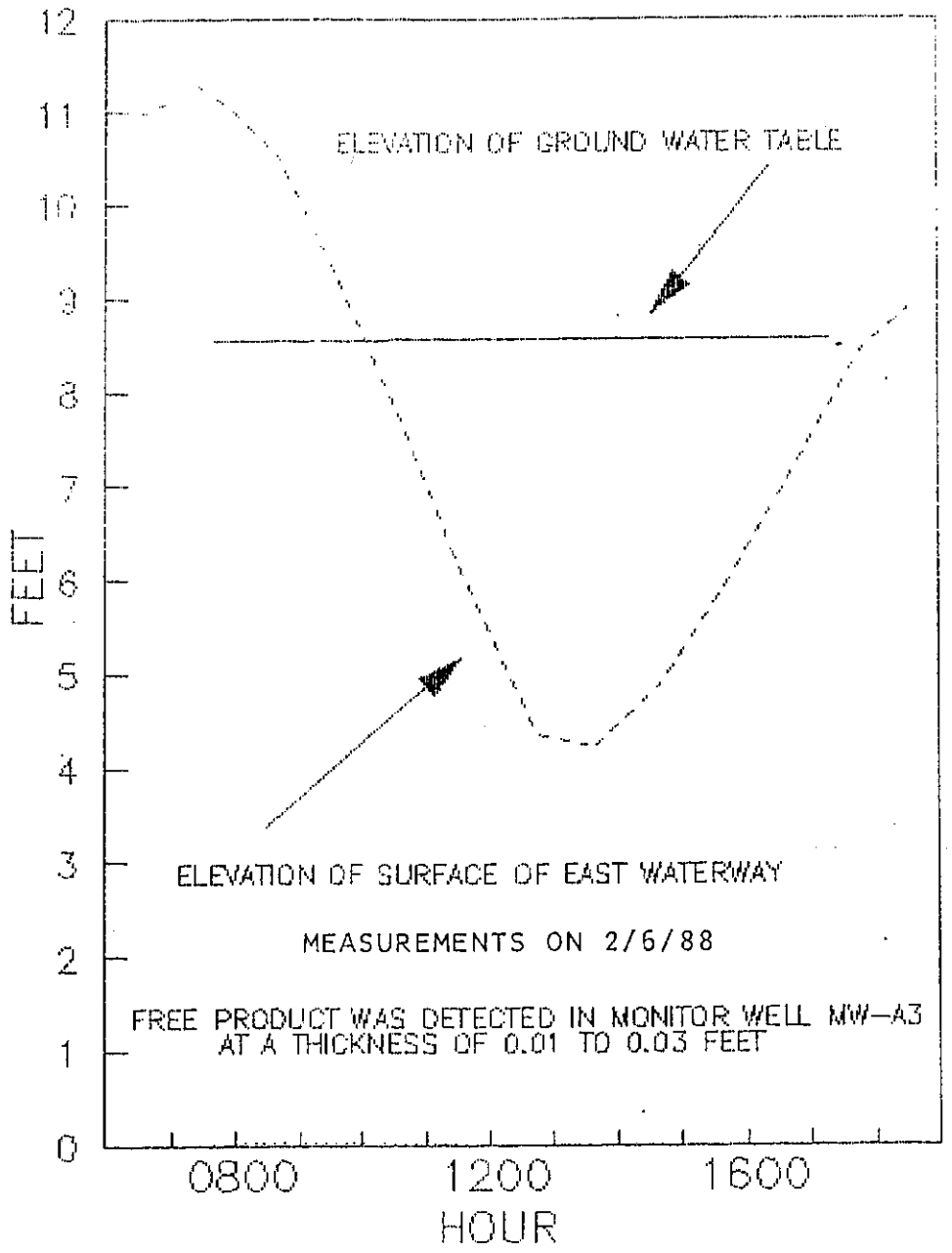
FIGURE A-46

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A3



GeoEngineers	PLOT OF WATER ELEVATIONS– MONITOR WELL MW– A3
	FIGURE A-47

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A4



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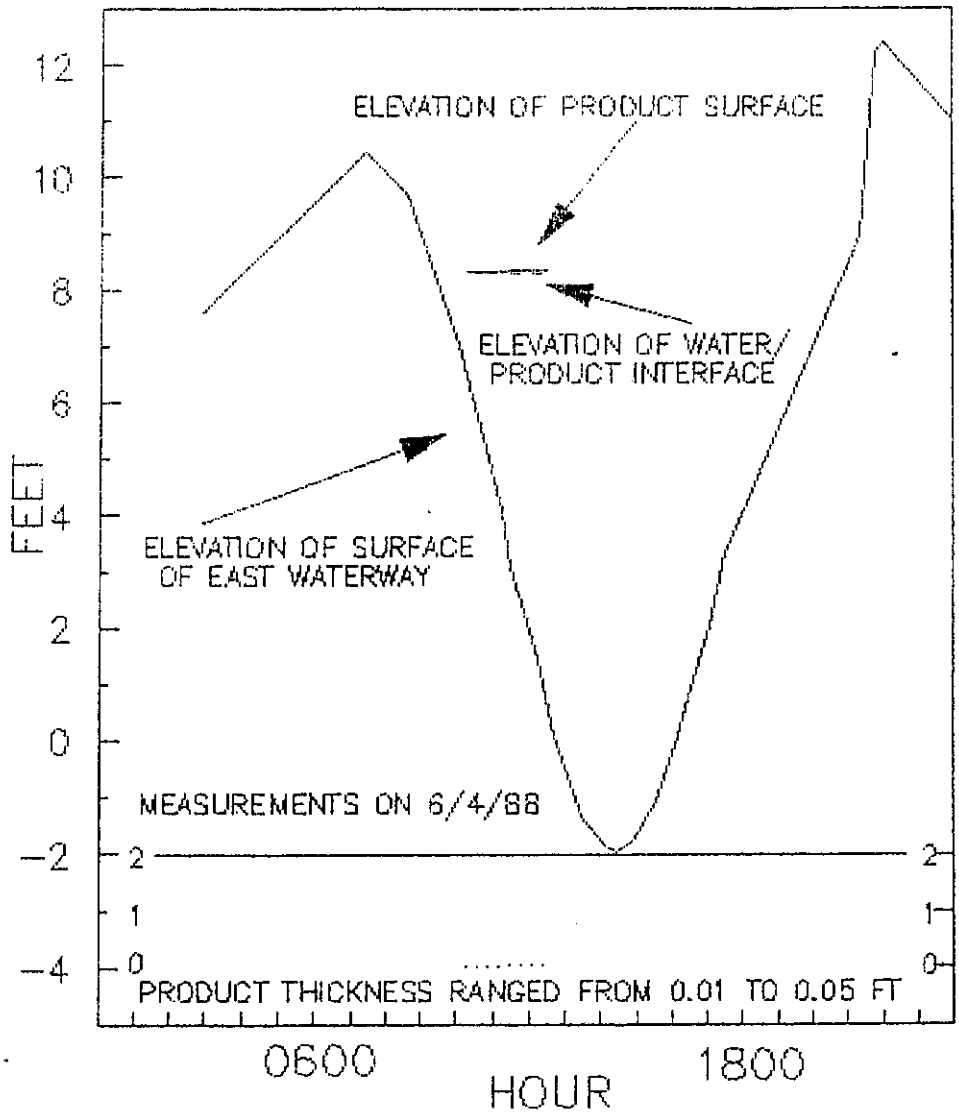
PLOT OF WATER ELEVATIONS-MONITOR WELL MW-A4

FIGURE A-48

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A4



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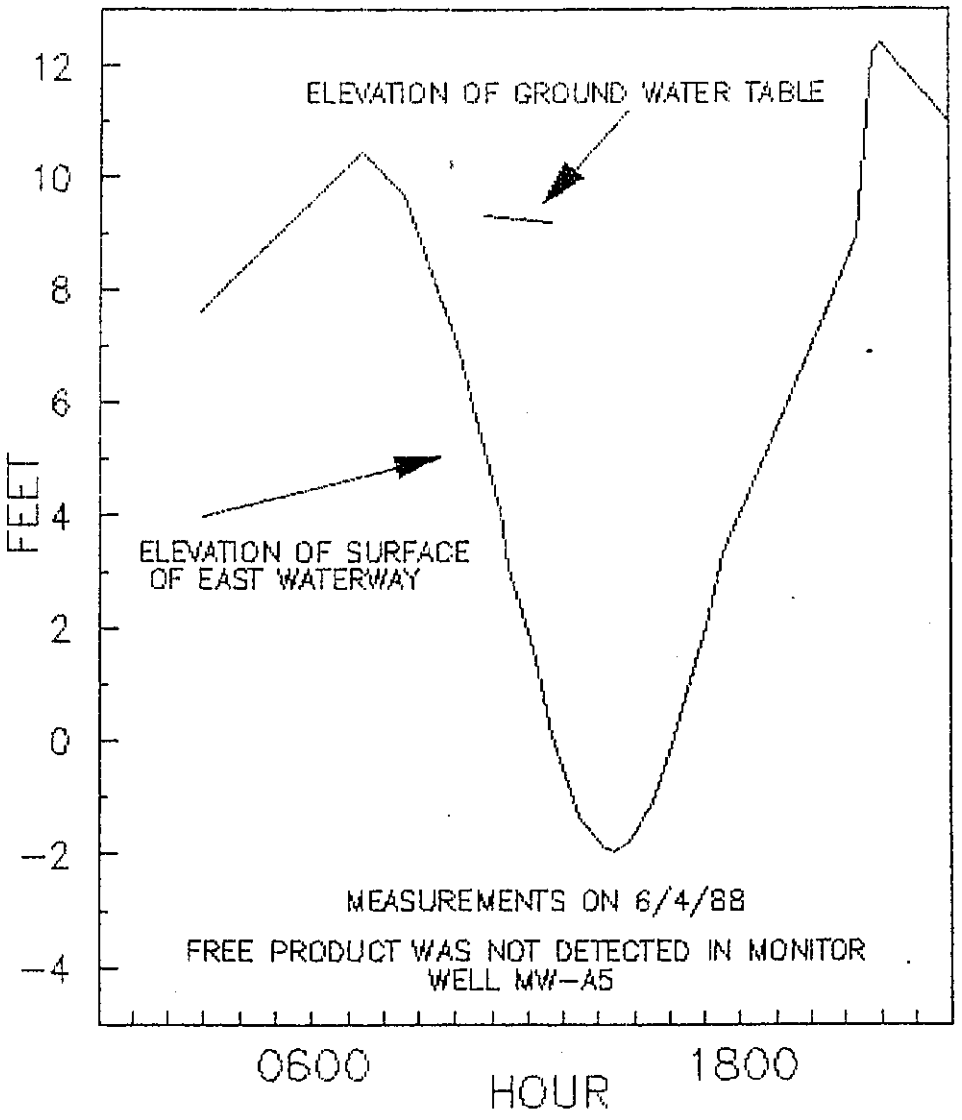
**PLOT OF WATER ELEVATIONS-
MONITOR WELL MW-A4**

FIGURE A-49

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A5



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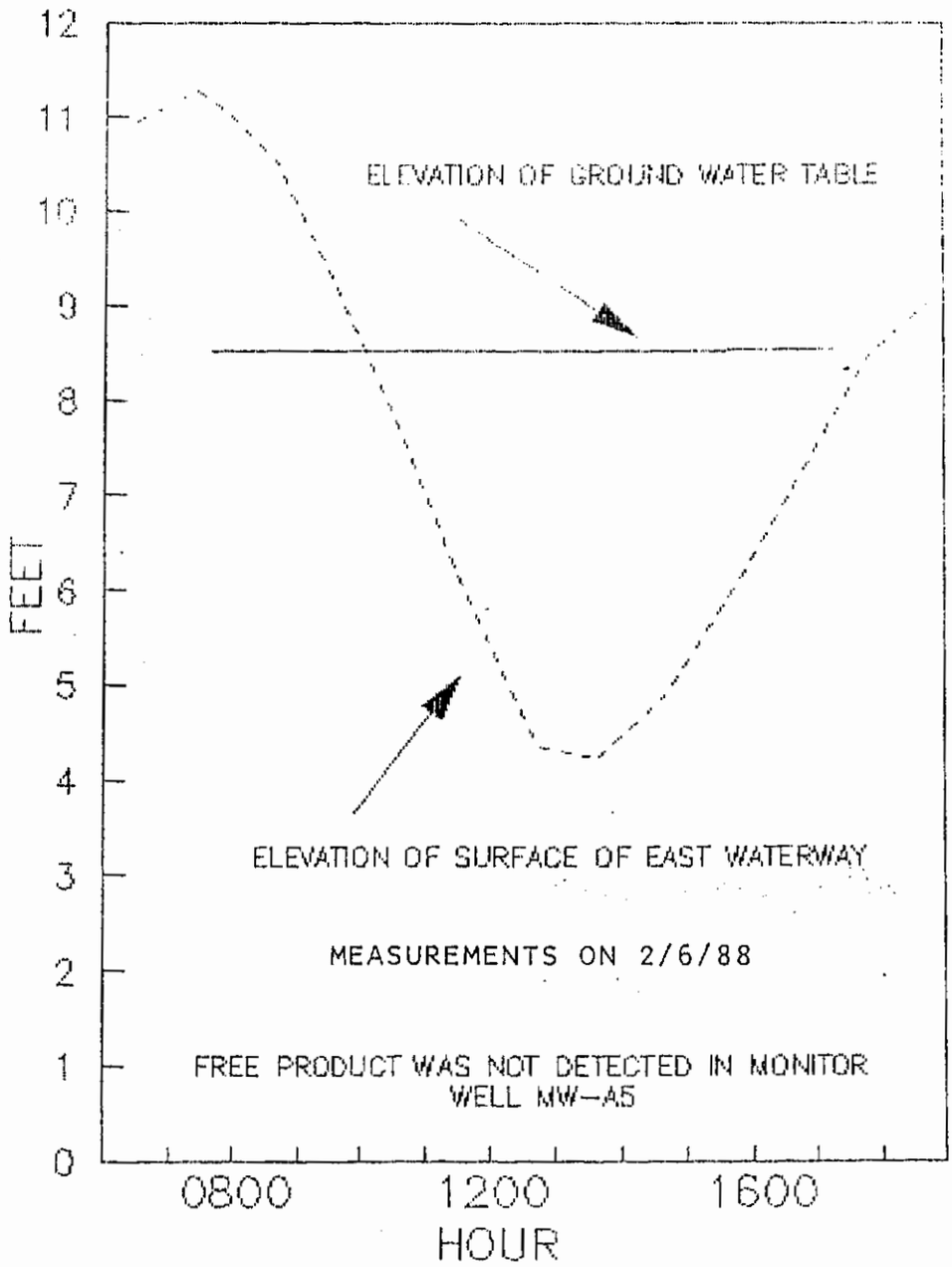
**PLOT OF WATER ELEVATIONS–
MONITOR WELL MW–A5**

FIGURE A–50

PORT OF SEATTLE – TERMINAL 18
MONITOR WELL MW–A5



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PLOT OF WATER ELEVATIONS-MONITOR WELL MW-A5

FIGURE A-51

GeoEngineers

APPENDIX B

Analytical Technologies, Inc. Corporate Offices 5550 Morehouse Drive San Diego, CA 92121 (619) 458-9141

ATI I.D. 802018

February 17, 1988

Geo Engineers
2405 140th NE Street Suite 105
Bellevue, Washington 98005

Project No.: 0303-24-4

Attention: John Biggane

On February 2, 1988, Analytical Technologies, Inc. received ten water samples, a trip blank, and one petroleum product for analyses. The samples were analyzed with EPA methodology or equivalent methods as specified in the attached analytical schedule. Please see the attached sheet for the sample cross reference.

The results and sample cross reference are enclosed.

Marcilen Lindsey
Inorganics Supervisor

Richard M. Amano
Laboratory Manager

ML:tka

ATI I.D. 802018

ANALYTICAL SCHEDULE

CLIENT : GEO ENGINEERS
PROJECT NAME : (NONE)

PROJECT NO.: 0303-24-4

ANALYSIS	TECHNIQUE	REFERENCE/METHOD
FLASH POINT	PENSKY-MARTENS (CLOSED CUP)	EPA 1010 (MODIFIED)
API GRAVITY AT 60 F	HYDROMETER	ASTM D287
LEAD	AA/GF	EPA 7421
ORGANIC LEAD	AA/GF	EPA 7421
PURGEABLE AROMATICS	GC/PID	EPA 8020

CLIENT : GEO ENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME : (NONE)

DATE RECEIVED : 02/02/88
REPORT DATE : 02/17/88

ATI I.D. : 802018

ATI #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	MW-1	WATER	01/30/88
02	MW-2	WATER	01/30/88
03	MW-3	WATER	01/30/88
04	MW-4	WATER	01/30/88
05	MW-5	WATER	01/30/88
06	MW-6	WATER	01/30/88
07	MW--8	WATER	01/30/88
08	MW-9	WATER	01/30/88
09	RINSATE	WATER	01/30/88
10	BLIND	WATER	01/30/88
11	MW-7	NON-AQUEOUS	01/30/88
12	TRIP BLANK	WATER	01/30/88

----- TOTALS -----

MATRIX	# SAMPLES
WATER	11
NON-AQUEOUS	1

ATI STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.

GENERAL CHEMISTRY RESULTS

ATI I.D. : 802018

CLIENT : GEO ENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME : (NONE)

DATE RECEIVED : 02/02/88
REPORT DATE : 02/17/88

PARAMETER	UNITS	11
API GRAVITY AT 60 DEGREES F		35.5
FLASH POINT	FAHREN	84

GENERAL CHEMISTRY - QUALITY CONTROL

CLIENT : GEO ENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME : (NONE) ATI I.D. : 802018

PARAMETER	UNITS	ATI I.D.	SAMPLE RESULT	DUP. RESULT	RPD	SPIKED SAMPLE	SPIKE CONC	% REC
API GRAVITY		80201811	35.5	35.5	0	N/A	N/A	N/A
FLASH POINT	FAHREN	80206001	>180	>180	0	N/A	N/A	N/A

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$

METALS RESULTS

ATI I.D. : 802018

CLIENT : GEO ENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME : (NONE)

DATE RECEIVED : 02/02/88
REPORT DATE : 02/17/88

PARAMETER	UNITS	01	02	03	04	05
ORGANIC LEAD	MG/L	<0.01	<0.01	<0.01	<0.01	<0.01
LEAD	MG/L	0.004	<0.002	<0.002	<0.002	<0.002

METALS RESULTS

ATI I.D. : 802018

CLIENT : GEO ENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME : (NONE)

DATE RECEIVED : 02/02/88
REPORT DATE : 02/17/88

PARAMETER	UNITS	06	07	08	09	10
ORGANIC LEAD	MG/L	<0.01	<0.01	<0.01	<0.01	<0.01
LEAD	MG/L	<0.008	<0.002	<0.008	<0.002	<0.008

METALS - QUALITY CONTROL

CLIENT : GEO ENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME : (NONE) ATI I.D. : 802018

PARAMETER	UNITS	ATI I.D.	SAMPLE RESULT	DUP. RESULT	RPD	SPIKED SAMPLE	SPIKE CONC	% REC
LEAD	MG/L	80201807	<0.01	<0.01	0	0.043	0.050	86
LEAD	MG/L	80201808	<0.002	<0.002	0	0.043	0.050	86

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201801

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-1	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	0.71
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	N/A
TRIFLUOROTOLUENE (%)	103

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201802

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-2	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	0.91
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	102
TRIFLUOROTOLUENE (%)	-*

* Result out of limits due to sample matrix interference

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201803

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-3	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	350
TOLUENE	7.1
CHLOROBENZENE	<0.5
ETHYLBENZENE	0.90
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	26
ORTHO & PARA XYLENE	46
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	95
TRIFLUOROTOLUENE (%)	167 *

* Result out of limits due to sample matrix interference

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201804

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-4	DATE ANALYZED	: 02/11/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 10

COMPOUNDS	RESULTS
BENZENE	<5.0
TOLUENE	<5.0
CHLOROBENZENE	<5.0
ETHYLBENZENE	<5.0
1,3-DICHLOROBENZENE	<5.0
1,2 AND 1,4-DICHLOROBENZENE	<5.0
META XYLENE	11
ORTHO & PARA XYLENE	43
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	72
TRIFLUOROTOLUENE (%)	99

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201805

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-5	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	1.2
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	0.98
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	N/A
TRIFLUOROTOLUENE (%)	115

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201806

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-6	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	0.76
CHLOROBENZENE	<0.5
ETHYLBENZENE	1.3
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	0.95
ORTHO & PARA XYLENE	0.94
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	105
TRIFLUOROTOLUENE (%)	125

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201807

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW--8	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	N/A
TRIFLUOROTOLUENE (%)	102

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201808

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-9	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	1.2
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	100
TRIFLUOROTOLUENE (%)	96

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201809

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: RINSATE	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	99
TRIFLUOROTOLUENE (%)	85

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201810

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: BLIND(MW-6)	DATE ANALYZED	: 02/06/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	1.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	1.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	1.2
ORTHO & PARA XYLENE	1.0
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	99
TRIFLUOROTOLUENE (%)	122

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201812

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: N/A
CLIENT I.D.	: TRIP BLANK	DATE ANALYZED	: 02/12/88
SAMPLE MATRIX	: WATER	UNITS	: UG/L
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5
SURROGATE PERCENT RECOVERIES	
BROMOCHLOROMETHANE (%)	N/A
TRIFLUOROTOLUENE (%)	105

GAS CHROMATOGRAPHY - RESULTS

REAGENT BLANK

TEST : VOLATILE AROMATICS (EPA METHOD 602)

CLIENT	: GEO ENGINEERS	ATI I.D.	: 802018
PROJECT #	: 0303-24-4	DATE EXTRACTED	: 02/06/88
PROJECT NAME	: (NONE)	DATE ANALYZED	: 02/06/88
CLIENT I.D.	: REAGENT BLANK	UNITS	: UG/L
		DILUTION FACTOR	: N/A

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

BROMOCHLOROMETHANE (%)	103
TRIFLUOROTOLUENE (%)	105

GAS CHROMATOGRAPHY - RESULTS

REAGENT BLANK

TEST : VOLATILE AROMATICS (EPA METHOD 602)

		ATI I.D.	: 802018
CLIENT	: GEO ENGINEERS	DATE EXTRACTED	: 02/10/88
PROJECT #	: 0303-24-4	DATE ANALYZED	: 02/10/88
PROJECT NAME	: (NONE)	UNITS	: UG/L
CLIENT I.D.	: REAGENT BLANK	DILUTION FACTOR	: N/A

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

BROMOCHLOROMETHANE (%)	80
TRIFLUOROTOLUENE (%)	99

GAS CHROMATOGRAPHY - RESULTS

REAGENT BLANK

TEST : VOLATILE AROMATICS (EPA METHOD 602)

		ATI I.D.	: 802018
CLIENT	: GEO ENGINEERS	DATE EXTRACTED	: 02/06/88
PROJECT #	: 0303-24-4	DATE ANALYZED	: 02/06/88
PROJECT NAME	: (NONE)	UNITS	: UG/L
CLIENT I.D.	: REAGENT BLANK	DILUTION FACTOR	: N/A

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

BROMOCHLOROMETHANE (%)	79
TRIFLUOROTOLUENE (%)	96

GAS CHROMATOGRAPHY - RESULTS

REAGENT BLANK

TEST : VOLATILE AROMATICS (EPA METHOD 602)

		ATI I.D.	: 802018
CLIENT	: GEO ENGINEERS	DATE EXTRACTED	: 02/12/88
PROJECT #	: 0303-24-4	DATE ANALYZED	: 02/12/88
PROJECT NAME	: (NONE)	UNITS	: UG/L
CLIENT I.D.	: REAGENT BLANK	DILUTION FACTOR	: N/A

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 AND 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

BROMOCHLOROMETHANE (%)	N/A
TRIFLUOROTOLUENE (%)	104

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201811

TEST : FUEL HYDROCARBONS (MODIFIED EPA METHOD 8015)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: 02/03/88
CLIENT I.D.	: MW-7	DATE ANALYZED	: 02/05/88
SAMPLE MATRIX	: NON-AQUEOUS	UNITS	: MG/KG
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
FUEL HYDROCARBONS	99 + %
HYDROCARBON RANGE	C6-C20
HYDROCARBONS QUANTITATED USING	DIESEL

SAMPLE NO.: OH01011A.01

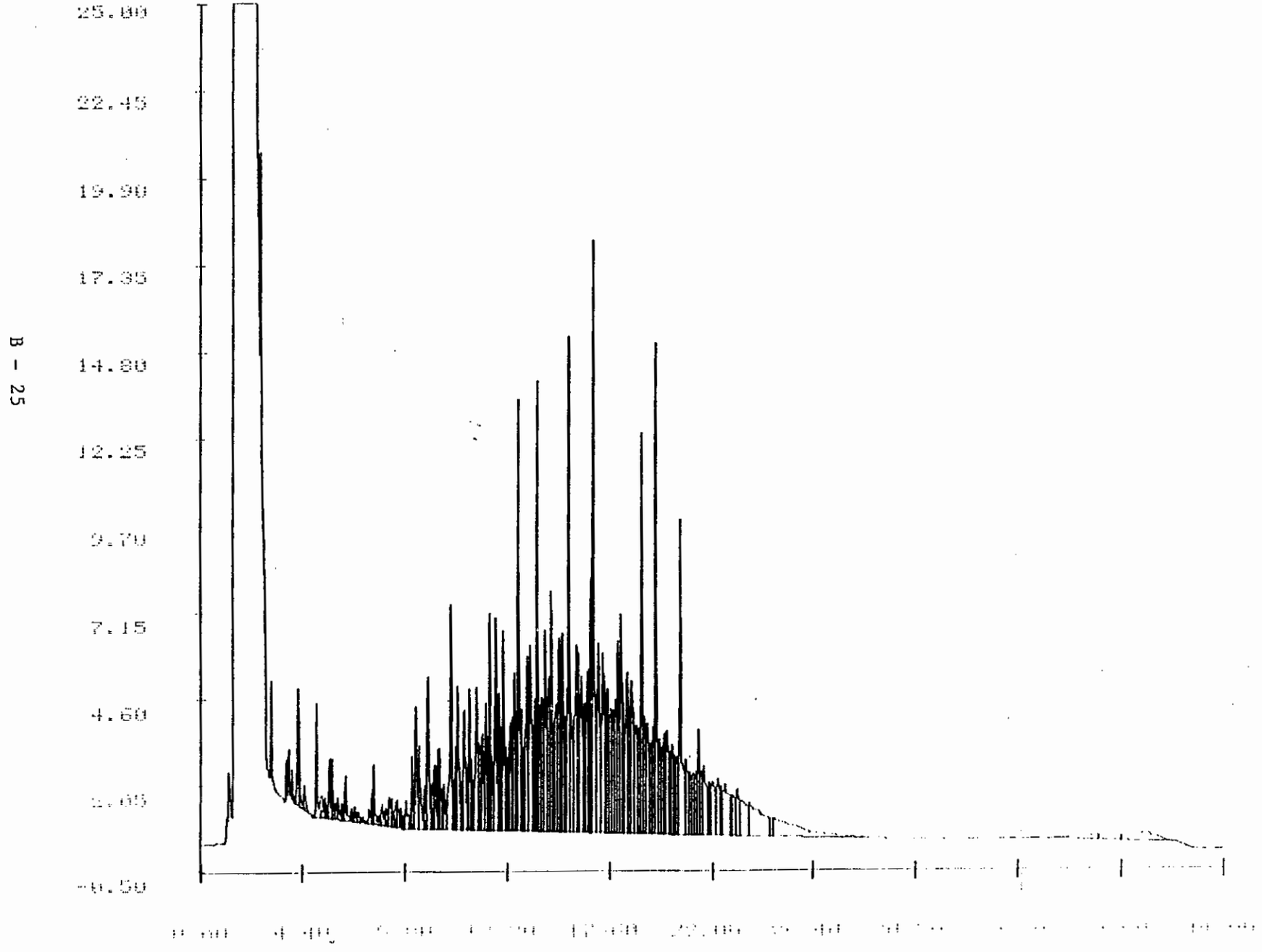
TEST NO.:

METHOD NO.: GBA2 / GBA2

INSTRUMENT: G7

DATE TIME: 02-03-03 09:41:08

PAGE NO.: 11

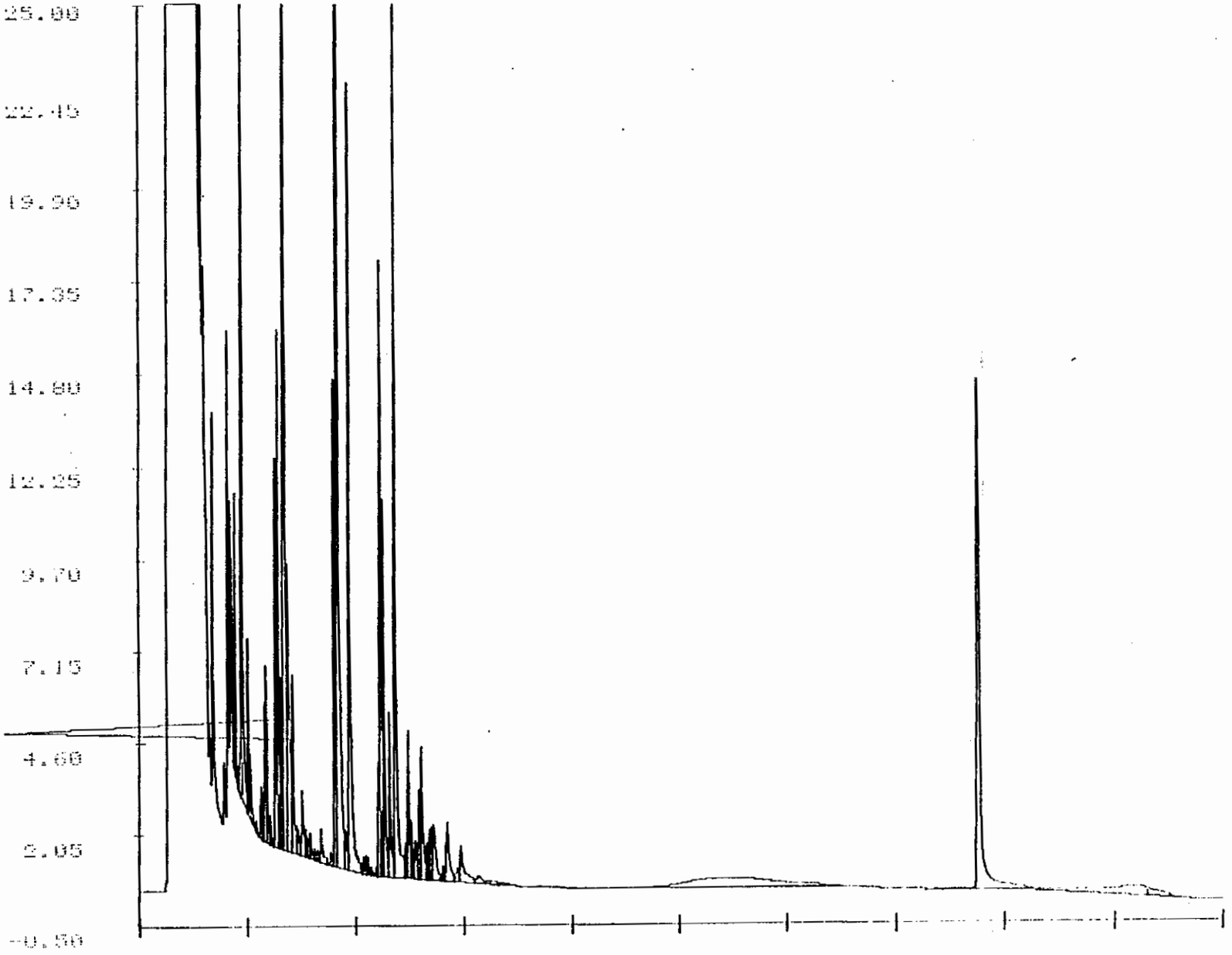


GAS STD 1105A HP

SAMPLE NO.: GAHP105A.01

TEST NO.:

METHOD NO.: GDA2 / GDA2

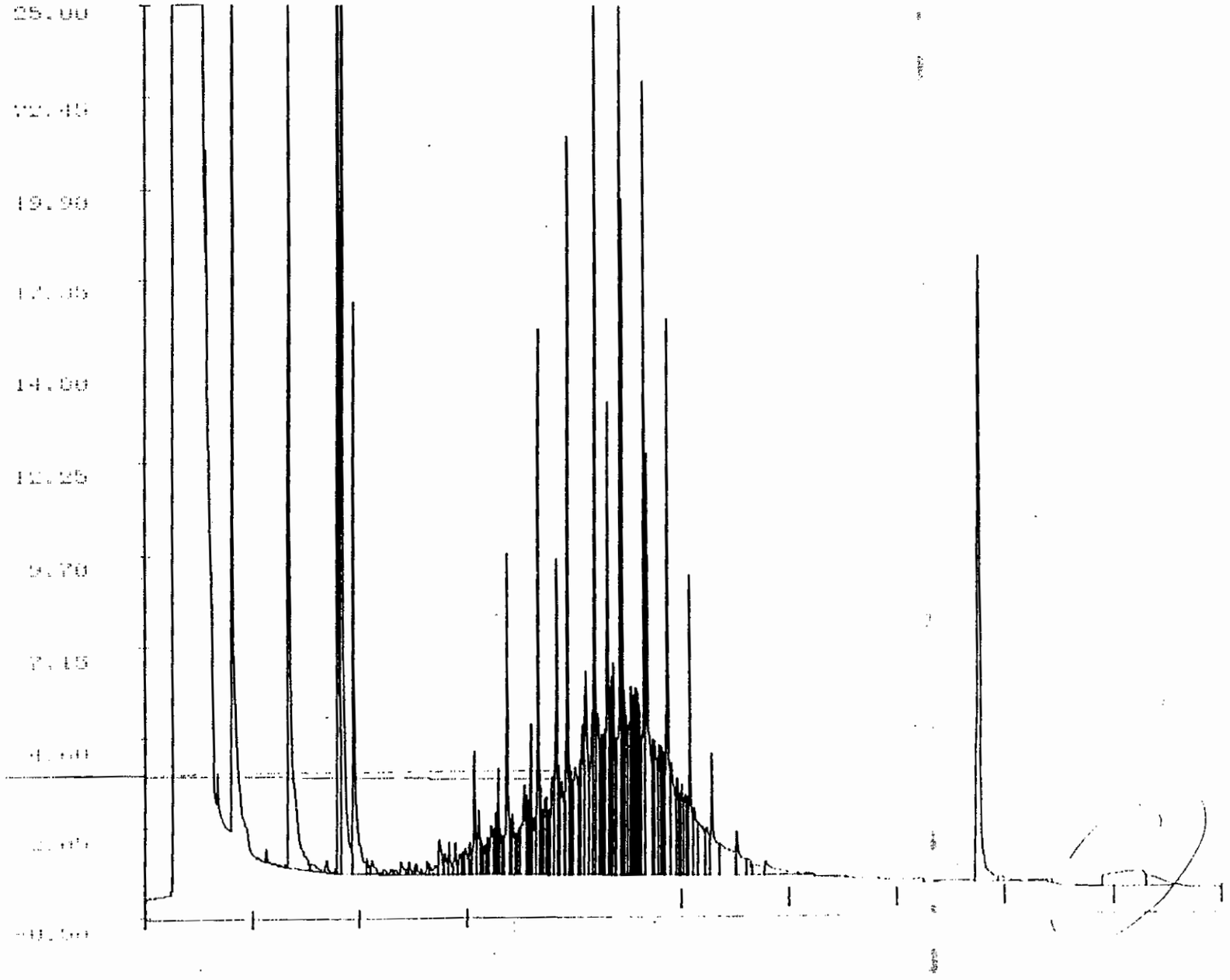


DIESEL STD 1105A HP

SAMPLE NO.: DEHP105A.01

TEST NO.:

METHOD NO.: GUM2 . GDA2



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DATE 1-1-93 PAGE 1 OF 4

PROJ. MGR. [illegible]

COMPANY GEO-ENGINEERS

ADDRESS 2405 [illegible] AVE NE

[illegible], WA [illegible]

SAMPLERS (SIGNATURE) [illegible] (PHONE NO.) (206) 746-5200

ANALYSIS REQUEST

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418	[illegible]	[illegible]	PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA-INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE				NUMBER OF CONTAINERS
MW 1	1-20-93	10:45	H_2O												X										1
MW 1	1-20-93	10:45	H_2O													X									1
MW 1	1-20-93	10:45	H_2O								X														2
MW 2	1-20-93	12:10	H_2O												X										1
MW 2	1-20-93	12:10	H_2O													X									1
MW 2	1-20-93	12:10	H_2O								X														2
MW 3	1-20-93	1:02	H_2O												X										1
MW 3	1-20-93	1:02	H_2O													X									1
MW 3	1-20-93	1:02	H_2O								X														2

PROJECT INFORMATION	
PROJECT:	0302-24-4
PO NO.	7057-70271
SHIPPING ID. NO.	1227-6512-0
VIA:	FEDERAL EXPRESS

SAMPLE RECEIPT	
TOTAL NO. OF CONTAINERS	
CHAIN OF CUSTODY SEALS	
REC'D GOOD CONDITION/COLD	
CONFORMS TO RECORD	
LAB NO.	

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
(Signature) [illegible] (Time)	(Signature) (Time)	(Signature) (Time)
(Printed Name) Cheryl Haines (Date) 1/22/93	(Printed Name) (Date)	(Printed Name) (Date)
(Company) GeoEngineers	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
(Signature) Marian VanDerhoef (Time)	(Signature) (Time)	(Signature) (Time)
(Printed Name) MARIAN VANDERHOEF (Date) 1/23	(Printed Name) (Date)	(Printed Name)
(Company) ATI	(Company)	ANALYTICAL TECHNOLOGIES, INC.

ATI LABORATORIES: SAN DIEGO (619) 458-9141 PHOENIX (602) 438-1530

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DATE 2-1-95 PAGE 2 OF 4

PROJ. MGR. JOHN BIGHAM
COMPANY GEOENGINEERS
ADDRESS 2405 140TH AVE N.E.
BELLEVUE WA 98005

SAMPLERS (SIGNATURE) (PHONE NO.)
Cheryl Haines (206) 746-9200

ANALYSIS REQUEST

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418	T-TPH-Gas	D-TPH-Fuel	PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA-INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE	NUMBER OF CONTAINERS
MW-4	1-30-95	1408	H_2O												X							1
MW-4	1-30-95	1408	H_2O													X						1
MW-4	1-30-95	1408	H_2O								X											2
MW-5	1-30-95	1555	H_2O												X							1
MW-5	1-30-95	1555	H_2O													X						1
MW-5	1-30-95	1555	H_2O								X											2
MW-6	1-30-95	1946	H_2O												X							1
MW-6	1-30-95	1946	H_2O													X						1
MW-6	1-30-95	1946	H_2O								X											2

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT: 0202-24-4	TOTAL NO. OF CONTAINERS	
PO NO. 7057570881	CHAIN OF CUSTODY SEALS	
SHIPPING ID. NO. 1227-6518-0	REC'D GOOD CONDITION/COLD	
VIA: FED Express	CONFORMS TO RECORD	
	LAB NO.	

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
Cheryl Haines 11:45		
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Cheryl Haines 2/1/95		
(Printed Name) (Date)	(Printed Name) (Date)	(Printed Name) (Date)
GeoEngineers		
(Company)	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
Marian Van Deerlooi		
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Marian VanDeerlooi		
(Printed Name) 2/3 (Date)	(Printed Name) (Date)	(Printed Name)
ATL		
(Company)	(Company)	ANALYTICAL TECHNOLOGIES, INC

ATI LABORATORIES: SAN DIEGO (619) 458-9141 PHOENIX (602) 438-1530

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DATE 2-1-88 PAGE 1 OF 1

PROJ. MGR. Tony Pipitone
COMPANY GeoEngineers
ADDRESS 2405 140th Ave N.E.
Bellevue, WA 98005

SAMPLERS (SIGNATURE) (PHONE NO.)
Cheryl Hanna (206) 746-5200

ANALYSIS REQUEST

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418	Ti [illegible]	[illegible]	PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA-INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE				NUMBER OF CONTAINERS
MW-4	1-27-88	1825	H_2O													X									1
MW-9	1-27-88	1825	H_2O								X														2
BLIND	1-30-88	—	H_2O												X										1
BLIND	1-30-88	—	H_2O													X									1
BLIND	1-30-88	—	H_2O								X														2

PROJECT INFORMATION

PROJECT: 0302-24-4
PO NO. 7057-7032-1
SHIPPING ID. NO. 1237-6518-0
VIA: FED Express

SAMPLE RECEIPT

TOTAL NO. OF CONTAINERS	
CHAIN OF CUSTODY SEALS	
REC'D GOOD CONDITION/COLD	
CONFORMS TO RECORD	
LAB NO.	

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
Cheryl Hanna 11:3		
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Cheryl Hanna 2/1/88		
(Printed Name) (Date)	(Printed Name) (Date)	(Printed Name) (Date)
GeoEngineers		
(Company)	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
Marian Vander Hoek		
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
MARIAN VANDERHOEK		
(Printed Name) ATI 2/2/88 (Date)	(Printed Name) (Date)	(Printed Name)
(Company)	(Company)	ANALYTICAL TECHNOLOGIES, INC.

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DATE 2-1-88 PAGE 3 OF 4

PROJ. MGR. John Riggane
COMPANY GeoEngineers
ADDRESS 2405 140th Ave N.E.
Bellevue, WA 98005

SAMPLERS (SIGNATURE) Cheryl Haines (PHONE NO.) (206) 746-5200

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418	[illegible]	[illegible]	PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA-INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE	Product Type API Gravity Flash Pt			NUMBER OF CONTAINERS
Rinsate	1-30-88	1504	H_2O												X									1
Rinsate	1-30-88	1504	H_2O													X									1
Rinsate	1-30-88	1504	H_2O								X														2
MW-7	1-30-88	2045	Petroleum product																		X			2
MW-8	1-30-88	1710	H_2O												X									1
MW-8	1-30-88	1710	H_2O													X								1
MW-8	1-30-88	1710	H_2O								X													2
MW-9	1-30-88	1825	H_2O												X									1

PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT: 0-02-24-4	TOTAL NO. OF CONTAINERS	
PO NO. 7057570221	CHAIN OF CUSTODY SEALS	
SHIPPING ID. NO. 1227-6518-0	REC'D GOOD CONDITION/COLD	
VIA: FED Express	CONFORMS TO RECORD	
	LAB NO.	

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
Cheryl Haines 11:13 (Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Cheryl Haines 2/1/88 (Printed Name) (Date)	(Printed Name) (Date)	(Printed Name) (Date)
GeoEngineers (Company)	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
Miriam VanDeKamp (Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Miriam VanDeKamp (Printed Name) ATI 2/1/88 (Date)	(Printed Name) (Date)	(Printed Name)
(Company)	(Company)	ANALYTICAL TECHNOLOGIES, INC.

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Analytical Technologies, Inc. Corporate Offices 5550 Morehouse Drive San Diego, CA 92121 (619) 458-9141

ATI I.D. 802018

March 17, 1988

Geo Engineers
2405 140th NE Street Suite 105
Bellevue, Washington 98005

Project No.: 0303-24-4

Attention: John Biggane

Enclosed please find an amended data sheet for the fuel hydrocarbon analyses.

If you have any other questions, please feel free to call (619) 458-9141.

Patricia A. Schroder
GC Supervisor

For: Richard M. Amano
Laboratory Manager

PS:mag

Analytical Technologies, Inc.

GAS CHROMATOGRAPHY - RESULTS

ATI I.D. : 80201811

TEST : FUEL HYDROCARBONS (MODIFIED EPA METHOD 8015)

CLIENT	: GEO ENGINEERS	DATE SAMPLED	: 01/30/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 02/02/88
PROJECT NAME	: (NONE)	DATE EXTRACTED	: 02/03/88
CLIENT I.D.	: MW-7	DATE ANALYZED	: 02/05/88
SAMPLE MATRIX	: NON-AQUEOUS	UNITS	: MG/KG
		DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
FUEL HYDROCARBONS	99 + %
HYDROCARBON RANGE	C6-C20
HYDROCARBONS QUANTITATED USING	DIESEL
ESTIMATED RATIO OF GASOLINE TO DIESEL (%)	10:90

Analytical Technologies, Inc. 560 Naches Avenue, S.W., Suite 101, Renton, WA 98055, (206) 228-8335

ATI I.D. #8805-034

June 14, 1988

GeoEngineers

JUN 15 1988

Routing

File 0303-24

Geoengineers, Inc.
2405 140th Ave. N.E.
Bellevue, WA 98005

Attention: John Biggane

Project Name:

Project Number: 0303-24-4

On May 16, 1988 Analytical Technologies, Inc. received 13 water samples for analyses. The samples were analyzed with EPA methodology or equivalent methods as specified in the attached analytical schedule. The results, sample cross reference, and the quality control data are enclosed.

Karen J. Mixon
Karen Mixon
GC Chemist

Frederick W. Grothkopp
Frederick W. Grothkopp
Technical Manager

FWG/hbb

ATI I.D. #8805-034

SAMPLE CROSS REFERENCE SHEET

CLIENT : GEOENGINEERS, INC.
PROJECT # : 0303-24-4
PROJECT NAME :

DATE RECEIVED : 05/16/88
REPORT DATE : 06/14/88

ATI #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
8805-034-1	MW-1	WATER	05/14/88
8805-034-2	MW-2	WATER	05/14/88
8805-034-3	MW-3	WATER	05/14/88
8805-034-4	MW-4	WATER	05/14/88
8805-034-5	MW-5	WATER	05/14/88
8805-034-6	MW-8	WATER	05/14/88
8805-034-7	MW-9	WATER	05/14/88
8805-034-8	MW-10	WATER	05/14/88
8805-034-9	MW-11	WATER	05/14/88
8805-034-10	RINSATE	WATER	05/14/88
8805-034-11	BLIND	WATER	05/14/88
8805-034-12	MW-12	WATER	05/14/88
8805-034-13	BLANK	WATER	05/14/88

----- TOTALS -----

MATRIX	# SAMPLES
WATER	13

ATI STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.

ATI I.D. #8805-034

ANALYTICAL SCHEDULE

CLIENT : GEOENGINEERS, INC. PROJECT #: 0303-24-4
PROJECT : PUGET POWER

ANALYSIS	TECHNIQUE	REFERENCE/METHOD
PURGEABLE AROMATICS	GC/PID	EPA 602
FUEL HYDROCARBONS	GC/FID	EPA 8015 (modified)
LEAD	AA/GF	EPA 7421

ATI I.D. #8805-034

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: N/A
PROJECT #	: 0303-24-4	DATE RECEIVED	: N/A
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: REAGENT BLANK	DATE ANALYZED	: 05/26/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 & 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

TRIFLUOROTOLUENE (%)	109

ATI I.D. #8805-034

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: N/A
PROJECT #	: 0303-24-4	DATE RECEIVED	: N/A
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: REAGENT BLANK	DATE ANALYZED	: 05/27/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 & 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

TRIFLUOROTOLUENE (%)	104

ATI I.D. #8805-034-8

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: 05/14/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 05/16/88
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-10	DATE ANALYZED	: 05/26/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 25

COMPOUNDS	RESULTS
BENZENE	470
TOLUENE	29
CHLOROBENZENE	<12.5
ETHYLBENZENE	<12.5
1,3-DICHLOROBENZENE	<12.5
1,2 & 1,4-DICHLOROBENZENE	<12.5
META XYLENE	17
ORTHO & PARA XYLENE	16

SURROGATE PERCENT RECOVERIES

TRIFLUOROTOLUENE (%)	131

ATI I.D. #8805-034-9

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: 05/14/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 05/16/88
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-11	DATE ANALYZED	: 05/26/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 40

COMPOUNDS	RESULTS
BENZENE	2500
TOLUENE	48
CHLOROBENZENE	<20.0
ETHYLBENZENE	150
1,3-DICHLOROBENZENE	<20.0
1,2 & 1,4-DICHLOROBENZENE	<20.0
META XYLENE	73
ORTHO & PARA XYLENE	350

SURROGATE PERCENT RECOVERIES

TRIFLUOROTOLUENE (%)	137

ATI I.D. #8805-034-10

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: 05/14/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 05/16/88
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: RINSATE	DATE ANALYZED	: 05/27/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 & 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

TRIFLUOROTOLUENE (%)	99

ATI I.D. #8805-034-11

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: 05/14/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 05/16/88
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: BLIND (MW-11)	DATE ANALYZED	: 05/26/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 50

COMPOUNDS	RESULTS
BENZENE	2000
TOLUENE	<25
CHLOROBENZENE	<25
ETHYLBENZENE	51
1,3-DICHLOROBENZENE	<25
1,2 & 1,4-DICHLOROBENZENE	<25
META XYLENE	<25
ORTHO & PARA XYLENE	150

SURROGATE PERCENT RECOVERIES	
TRIFLUOROTOLUENE (%)	101

Analytical Technologies, Inc.

ATI I.D. #8805-034-13

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: 05/14/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 05/16/88
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: BLANK - TRIP	DATE ANALYZED	: 05/27/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 & 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES	
TRIFLUOROTOLUENE (%)	93

ATI I.D. #8805-034

QUALITY CONTROL DATA
MATRIX SPIKE/MATRIX SPIKE DUPLICATES

CLIENT : GEOENGINEERS, INC.
PROJECT : 0303-24-4
SAMPLE I.D. : 80516901

SAMPLE MATRIX : WATER
UNITS : ug/L
EPA METHOD : 602

COMPONENT	SAMPLE RESULT	SPIKED ADDED	SPIKED SAMPLE	% REC	DUP SPIKED SAMPLE	DUP % REC	RPD
BENZENE	<0.5	8.0	7.1	89	6.9	86	3
TOLUENE	<0.5	8.0	6.9	86	7.7	96	11
ETHYLBENZENE	<0.5	8.0	7.3	91	8.1	101	10
META-ZYLENE	<0.5	23	21	92	23	100	9

ATI I.D. : 8805-034

METALS RESULTS

CLIENT : GEOENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME :

DATE RECEIVED : 05/16/88
REPORT DATE : 06/14/88

PARAMETER	UNITS	08	09	10	11
ORGANIC LEAD	MG/L	<0.01	<0.01	<0.01	<0.01
LEAD	MG/L	<0.002	<0.002	<0.002	<0.002

ATI I.D. : 8805-034

METALS QUALITY CONTROL

CLIENT : GEOENGINEERS, INC.
PROJECT # : 0303-24-4
PROJECT NAME :

PARAMETER	UNITS	ATI I.D.	SAMPLE RESULT	DUP. RESULT	RRD	SPIKED SAMPLE	SPIKE CONC	% REC
LEAD	MG/L	80514701	<0.01	<0.01	0	0.036	0.050	72
LEAD	MG/L	80516203	0.004	0.003	29	0.041	0.050	82

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{\text{Sample Result} - \text{Duplicate Result}}{\text{Average Result}} \times 100$$

ATI I.D. # 8805-034

GENERAL CHEMISTRY RESULTS

CLIENT : GEOENGINEERS
PROJECT # : 0303-24-4
PROJECT NAME :

DATE RECEIVED : 05/16/88
REPORT DATE : 06/14/88

PARAMETER	UNITS	01	02	03	04	05
PETROLEUM HYDROCARBONS	mg/L	0.27	0.3	1.9	0.13	0.40

ATI I.D. # 8805-034

GENERAL CHEMISTRY RESULTS

CLIENT : GEOENGINEERS, INC. DATE RECEIVED : 05/16/88
PROJECT # : 0303-24-4
PROJECT NAME : REPORT DATE : 06/14/88

PARAMETER	UNITS	06	07	08	09	10
PETROLEUM HYDROCARBONS	mg/L	<0.05	0.07	20.3	31.3	1.3

ATI I.D. # 8805-034

GENERAL CHEMISTRY RESULTS

CLIENT : GEOENGINEERS, INC.
PROJECT # : 0303-24-4
PROJECT NAME :

DATE RECEIVED : 05/16/88
REPORT DATE : 06/14/88

PARAMETER	UNITS	11	12	13
PETROLEUM HYDROCARBONS	mg/L	6.7		0.53
GRAVITY	API		33.8	
FLASH POINT, PMCC	DEG. F		82	

Analytical Technologies, Inc.

ATI I.D. # 8805-034

GENERAL CHEMISTRY QUALITY CONTROL

CLIENT : GEOENGINEERS, INC
PROJECT # : 0303-24-4
PROJECT NAME :

PARAMETER	UNITS	ATI ID	SAMPLE RSLT.	DUP. RSLT.	RPD	SPIKED RESULT	SPIKE ADDED	% REC
PETROLEUM HYDROCARBONS	mg/L	8805034-13				12.67	10	127
PETROLEUM HYDROCARBONS	mg/L	8804047-1	<0.05	0.06	18			

ATI I.D. #88050-034-12

FUEL HYDROCARBONS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: 05/14/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 05/16/88
PROJECT NAME	:	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-12	DATE ANALYZED	: 05/19/88
SAMPLE MATRIX	: PETROLEUM PRODUCT	UNITS	: N/A
EPA METHOD	: 8015 MODIFIED (GC/FID)	DILUTION FACTOR	:

COMPOUNDS	RESULTS
FUEL HYDROCARBONS	1 PART GAS 10 PART DIESEL

Analytical**Technologies,**Inc.
San Diego ● Phoenix ● Seattle

Chain of Custody

DATE 5-16-88 PAGE 1 OF 3

PROJ. MGR. John Biggane
COMPANY GeoEngineers, Inc.
ADDRESS 2405 140th Ave N.E.
Bellevue, WA 98005

SAMPLERS (SIGNATURE) Cheryl Haines (PHONE NO.) (206) 746-5200

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS; SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418	TPH 418.1		PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA-INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE				NUMBER OF CONTAINERS
MW-1	5-14-88 0925	0925	water	-1											X									1
MW-2	5-14-88	1022	"	-2											X									1
MW-3	5-14-88	1120	"	-3											X									1
MW-4	5-14-88	1215	"	-4											X									1
MW-5	5-14-88	1100	"	-5											X									1
MW-6	5-14-88	1257	"	-6											X									1
MW-9	5-14-88	1350	"	-7											X									1

ANALYSIS REQUEST

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PROJECT INFORMATION	
PROJECT:	
PO NO.	
SHIPPING ID. NO.	
VIA:	

SAMPLE RECEIPT	
TOTAL NO. OF CONTAINERS	7
CHAIN OF CUSTODY SEALS	/
REC'D GOOD CONDITION/COLD	✓
CONFORMS TO RECORD	✓
LAB NO.	8805-034

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
Cheryl Haines (Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Cheryl Haines (Printed Name) (Date)	(Printed Name) (Date)	(Printed Name) (Date)
GEI 5-16-88 (Company)	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
(Signature) (Time)	(Signature) (Time)	Michelle Cooley 1:13 (Signature) (Time)
(Printed Name) (Date)	(Printed Name) (Date)	Michelle Cooley (Printed Name)
(Company)	(Company)	ANALYTICAL TECHNOLOGIES, INC.

ATI LABORATORIES: SAN DIEGO (619) 458-9141 PHOENIX (602) 438-1530

DISTRIBUTION: WHITE, CANARY - ANALYTICAL TECHNOLOGIES, INC. ● PINK - ORIGINATOR

Analytical**Technologies,**Inc.
San Diego ● Phoenix ● Seattle

Chain of Custody

DATE 5-16-88 PAGE 3 OF 3

PROJ. MGR. John Biggane
COMPANY GEOENGINEERS, INC
ADDRESS 2405 140th Ave NE
Bellevue, WA 98005

SAMPLERS (SIGNATURE) (PHONE NO.)
Cheryl Haines (206) 746-5200

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418	TPH 418.1	TOTAL LEAD ORGANIC LEAD	PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA-INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE	Product type API gravity Flash Point			NUMBER OF CONTAINERS
BLIND	5-14-88		water	-11											X										1
BLIND	5-14-88		"	-11												X									1
BLIND	5-14-88		"	-11							X														2
MW-12	5-14-88	1715	~~Product~~ Petroleum	-12																		X			1
BLANK	5-14-88		water	-13											X										1
BLANK	5-14-88		"	-13							X														

ANALYSIS REQUEST

PROJECT INFORMATION
PROJECT: 0303-24-4
PO NO.
SHIPPING ID. NO.
VIA:

SAMPLE RECEIPT
TOTAL NO. OF CONTAINERS 10
CHAIN OF CUSTODY SEALS ✓
REC'D GOOD CONDITION/COLD ✓
CONFORMS TO RECORD ✓
LAB NO. 805-034

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
Cheryl Haines		
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Cheryl Haines 1301		
(Printed Name) (Date)	(Printed Name) (Date)	(Printed Name) (Date)
GEI 5-16-88		
(Company)	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
		Michelle Cooley 1345
(Signature) (Time)	(Signature) (Time)	(Signature) (Time)
		Michelle Cooley
(Printed Name) (Date)	(Printed Name) (Date)	(Printed Name)
(Company)	(Company)	ANALYTICAL TECHNOLOGIES, INC.

ATI LABORATORIES: SAN DIEGO (619) 458-9141 PHOENIX (602) 438-1530

DISTRIBUTION: WHITE, CANARY - ANALYTICAL TECHNOLOGIES, INC. ● PINK - ORIGINATOR

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Analytical**Technologies,**Inc.
San Diego ● Phoenix ● Seattle

Chain of Custody

DATE 5-16-88 PAGE 2 OF 3

PROJ. MGR. John BIGGANE
COMPANY GEOENGINEERS, INC
ADDRESS 2405 140th Ave NE
Bellevue, Wa 98005

SAMPLERS (SIGNATURE) (PHONE NO.)
Cheryl Haines (206) 746-5200

ANALYSIS REQUEST

SAMPLE ID.	DATE	TIME	MATRIX	LAB ID.	BASE/NEU/ACID CMPDS. GC/MS/ 625/8270	VOLATILE CMPDS. GC/MS/ 624/8240	PESTICIDES/PCB 608/8080	POLYNUCLEAR AROMATIC 610/8310	PHENOLS, SUB PHENOLS 604/8040	HALOGENATED VOLATILES 601/8010	AROMATIC VOLATILES 602/8020	TOTAL ORGANIC CARBON 415/9060	TOTAL ORGANIC HALIDES 9020	PETROLEUM HYDROCARBONS 418	418.1 TPH	Total Lead ORGANIC LEAD	PRIORITY POLLUTANT METALS (13)	CAM METALS (18) TTLC/STLC	EP TOX METALS (8)	SWDA-INORGANICS PRIMARY/SECONDARY	HAZARDOUS WASTE PROFILE				NUMBER OF CONTAINERS
MW-10	5-14-88	1430	water	-8							X														2
MW-10	5-14-88	1430	water	-8											X										1
MW-10	5-14-88	1430	water	-8												X									1
MW-11	5-14-88	1657	water	-9							X														2
MW-11	5-14-88	1657	"	-9											X										1
MW-11	5-14-88	1657	"	-9												X									1
Rinsate	5-14-88	1620	"	-10							X														2
Rinsate	5-14-88	1620	"	-10											X										1
Rinsate	5-14-88	1620	"	-10												X									1

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PROJECT INFORMATION	SAMPLE RECEIPT	
PROJECT: 0303-24-4	TOTAL NO. OF CONTAINERS	12
PO NO.	CHAIN OF CUSTODY SEALS	
SHIPPING ID. NO.	REC'D GOOD CONDITION/COLD	✓
VIA:	CONFORMS TO RECORD	✓
	LAB NO. 8805-034	

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY 1.	RELINQUISHED BY 2.	RELINQUISHED BY 3.
Cheryl Haines (Signature) (Time)	(Signature) (Time)	(Signature) (Time)
Cheryl Haines (Printed Name) (Date)	(Printed Name) (Date)	(Printed Name) (Date)
GEI 5-16-88 (Company)	(Company)	(Company)
RECEIVED BY 1.	**RECEIVED BY 2.**	**RECEIVED BY (LABORATORY) 3.**
(Signature) (Time)	(Signature) (Time)	Michele Cooley (Signature) (Time)
(Printed Name) (Date)	(Printed Name) (Date)	MICHELE COOLEY (Printed Name)
(Company)	(Company)	ANALYTICAL TECHNOLOGIES, INC.

ATI LABORATORIES: SAN DIEGO (619) 458-9141 PHOENIX (602) 438-1530

DISTRIBUTION: WHITE, CANARY - ANALYTICAL TECHNOLOGIES, INC. ● PINK - ORIGINATOR

Analytical Technologies, Inc. 560 Naches Avenue, S.W., Suite 101, Renton, WA 98055, (206) 228-8335

ATI I.D. # 8810-114

GeoEngineers

November 8, 1988

JHB

Geoengineers, Inc.
2405 140th Ave. N.E.
Suite 105
Bellevue, WA 98005

Attention : John Biggane

Project Number : 0303-24-4

Project Name : Port of Seattle; T-18

On October 28, 1988 Analytical Technologies, Inc. received one water sample for analysis. The sample was analyzed with EPA methodology or equivalent methods as specified in the attached analytical schedule. The results, sample cross reference, and the quality control data are enclosed.

Mary Silva
GC Chemist

Frederick W. Grothkopp
Technical Manager

FWG/hbb

ATI I.D. # 8810-114

SAMPLE CROSS REFERENCE SHEET

CLIENT : GEOENGINEERS, INC.
PROJECT # : 0303-24-4
PROJECT NAME : PORT OF SEATTLE; T-18

ATI #	CLIENT DESCRIPTION	MATRIX	DATE SAMPLED
8810-114-1	MW-13	WATER	10/28/88

----- TOTALS -----

MATRIX	# SAMPLES
WATER	1

ATI STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.

Analytical Technologies, Inc.

ATI I.D. # 8810-114

ANALYTICAL SCHEDULE

CLIENT : GEOENGINEERS, INC.
PROJECT # : 0303-24-4
PROJECT NAME : PORT OF SEATTLE; T-18

ANALYSIS	TECHNIQUE	REFERENCE/METHOD
PURGEABLE AROMATICS	GC/FID	EPA 602
PETROLEUM HYDROCARBONS	IR	EPA 418.1

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PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: N/A
PROJECT #	: 0303-24-4	DATE RECEIVED	: N/A
PROJECT NAME	: PORT OF SEATTLE; T-18	DATE EXTRACTED	: N/A
CLIENT I.D.	: REAGENT BLANK	DATE ANALYZED	: 11/03/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 1

COMPOUNDS	RESULTS
BENZENE	<0.5
TOLUENE	<0.5
CHLOROBENZENE	<0.5
ETHYLBENZENE	<0.5
1,3-DICHLOROBENZENE	<0.5
1,2 & 1,4-DICHLOROBENZENE	<0.5
META XYLENE	<0.5
ORTHO & PARA XYLENE	<0.5

SURROGATE PERCENT RECOVERIES

TRIFLUOROTOLUENE	101

ATI I.D. # 8810-114-1

PURGEABLE AROMATICS ANALYSIS
DATA SUMMARY

CLIENT	: GEOENGINEERS, INC.	DATE SAMPLED	: 10/28/88
PROJECT #	: 0303-24-4	DATE RECEIVED	: 10/28/88
PROJECT NAME	: PORT OF SEATTLE; T-18	DATE EXTRACTED	: N/A
CLIENT I.D.	: MW-13	DATE ANALYZED	: 11/03/88
SAMPLE MATRIX	: WATER	UNITS	: ug/L
EPA METHOD	: 602	DILUTION FACTOR	: 10 *

COMPOUNDS	RESULTS
BENZENE	<5.0
TOLUENE	6.5
CHLOROBENZENE	<5.0
ETHYLBENZENE	<5.0
1,3-DICHLOROBENZENE	<5.0
1,2 & 1,4-DICHLOROBENZENE	<5.0
META XYLENE	9.8
ORTHO & PARA XYLENE	<5.0

SURROGATE PERCENT RECOVERIES

TRIFLUOROTOLUENE	95

* Sample diluted due to presence of late eluting compounds.

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PURGEABLE AROMATICS
QUALITY CONTROL DATA

CLIENT	: GEOENGINEERS, INC.	SAMPLE I.D.	: 8810-092-5
PROJECT #	: 0303-24-4	DATE ANALYZED	: 10/26/88
PROJECT NAME	: PORT OF SEATTLE; T-18	UNITS	: ug/L
EPA METHOD	: 602	MATRIX	: WATER

COMPOUND	SAMPLE RESULT	SPIKE ADDED	SPIKED SAMPLE	% REC	DUP SPIKED SAMPLE	DUP % REC	RPD
BENZENE	<0.5	8.0	7.15	89	6.92	87	2
TOLUENE	<0.5	8.0	7.22	90	6.95	87	3
CHLOROBENZENE	<0.5	8.0	7.04	88	6.65	83	6
META-XYLENE	<0.5	12	10.70	89	10.36	86	3

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative \% Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$

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GENERAL CHEMISTRY RESULTS

CLIENT : GEOENGINEERS, INC. DATE RECEIVED : 10/28/88
PROJECT # : 0303-24-4
PROJECT NAME : PORT OF SEATTLE; T-18 SAMPLE MATRIX : WATER

PARAMETER	UNITS	-1
PETROLEUM HYDROCARBONS	mg/L	62

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GENERAL CHEMISTRY QUALITY CONTROL

CLIENT : GEOENGINEERS, INC. SAMPLE MATRIX : WATER
PROJECT # : 0303-24-4
PROJECT NAME : PORT OF SEATTLE; T-18

PARAMETER	UNITS	ATI I.D.	SAMPLE RESULT	DUP RESULT	RPD	SPIKED CONC	SPIKE ADDED	% REC
PETROLEUM HYDROCARBONS	mg/L	8810-093-56	<0.05	<0.05	0	N/A	N/A	N/A
PETROLEUM HYDROCARBONS	mg/L	WATER SPIKE	N/A	N/A	N/A	44.3	51.8	86

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative \% Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$